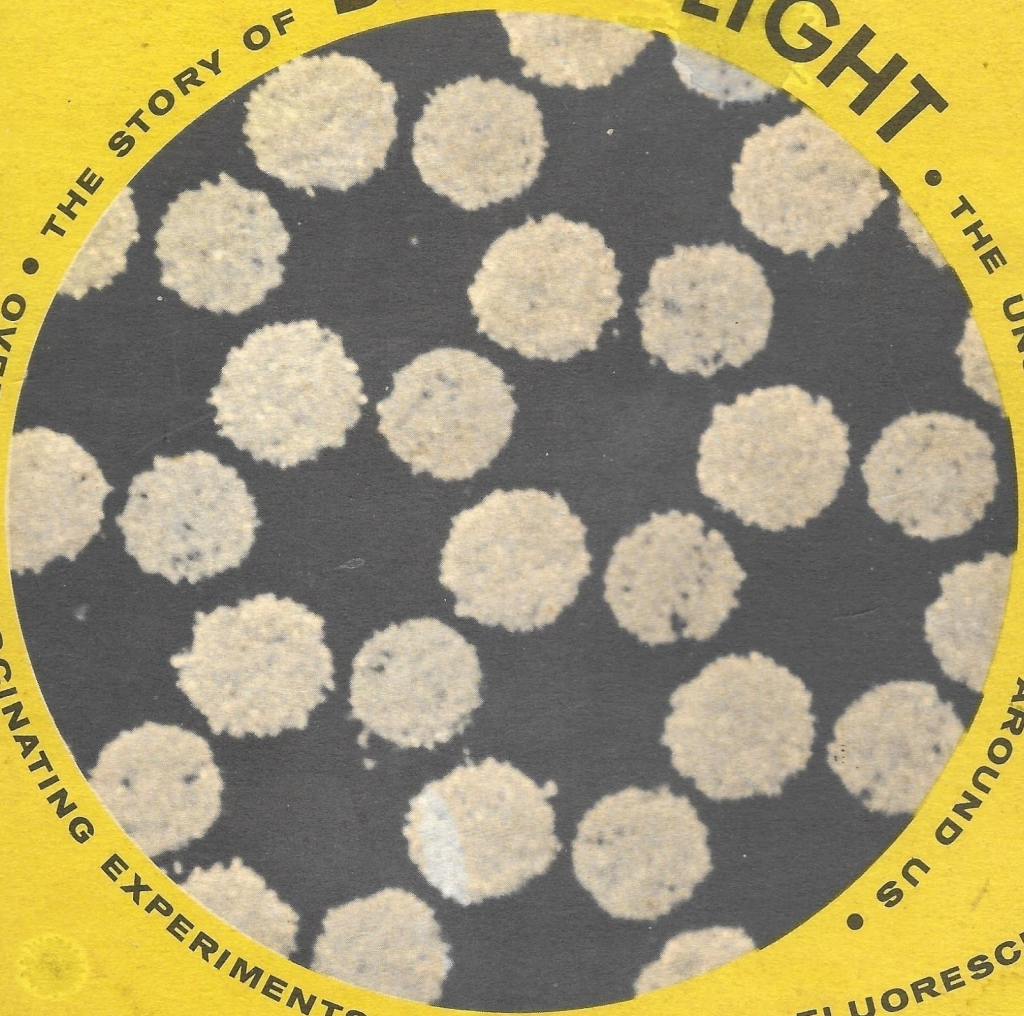
ULTRA VIOLET

THE STORY OF BLACK LIGHT



• THE UNSEEN WORLD AROUND US •

OVER 40 FASCINATING EXPERIMENTS IN ULTRA-VIOLET FLUORESCENCE

THE WORKSHOP
OF
STAN & JANE MAZUR

THE STORY OF BLACK LIGHT

The Unseen World Around Us

and a

Manual of Experiments in Ultraviolet Fluorescence

by

B. M. J. Kublar

Educational Director, Black Light Eastern Corp.

Illustrated by

William Alexander

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Safety engineer checks with black light lamp to detect minute traces of oil contamination on missile, fueled with liquid oxygen.

Front cover— One of earliest photomicrographs taken (1956) shows fluorescing color phosphor dots under filtered ultra-violet rays. One million of these dots cover the face of the average 21" color TV picture tube. (Photo credits: Eastman Kodak, Sylvania Electric Corp., Black Light Eastern Corp.).

Back Cover—Photomicrograph of fluorescent antibodies. Smear of spleen from a mouse infected with plague was stained with specific plague antibody and examined under ultra-violet light. (Photo courtesy Dr. Max D. Moody, Communicable Disease Center, Public Health Service.)

A Message From Mr. Kublar

TO THE BOYS AND GIRLS:

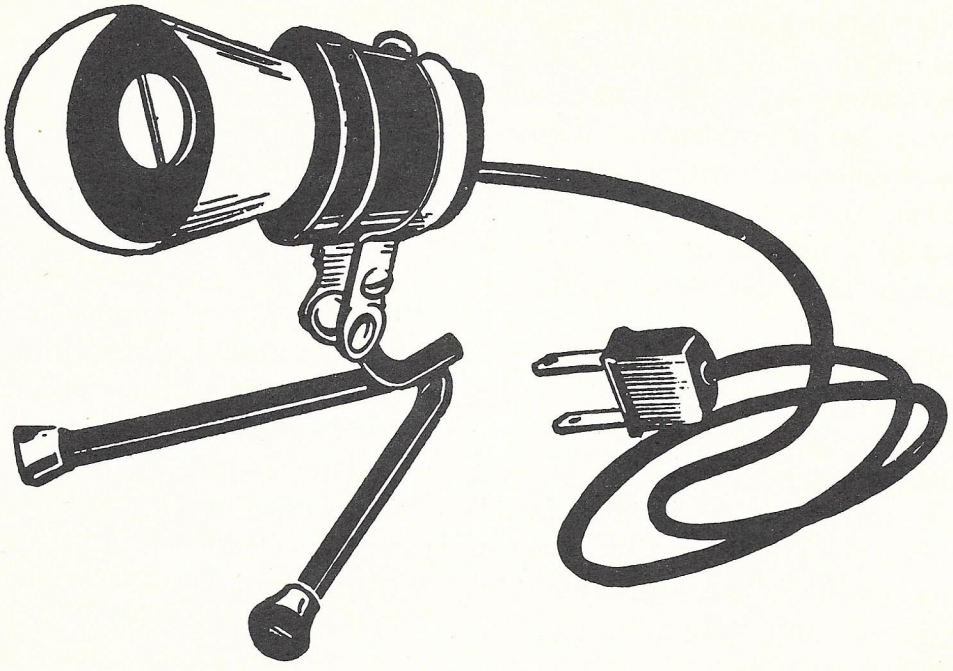
Welcome to the unseen world around us—to the fascination of ultra-violet fluorescence. The purpose of this kit is to open a door for you into the wonderful world of science, and to show you that this world is full of interest and excitement.

Today some of the most spectacular advances in medicine and science are being made with black light. We hope that your early interest in science will help you in a career that will enrich the world.

TO THE PARENTS AND TEACHERS:

This kit gives boys and girls an introduction to the wonder and science of ultra-violet fluorescence. It is designed to awaken in them an interest in science and the world around us. The Story of Black Light and the 42 experiments described in the kit will provide many hours of excitement, interesting study and just plain fun.

The chemicals and other materials in this kit are safe and nontoxic. They are as safe as many of the things with which you and your children come into contact, daily. The black-light lamp in this kit is likewise, completely safe and harmless to the eyes and skin.



Operating and Assembly Instructions for your Black Light and Universal Laboratory Lamp Stand

1. Place rubber tips on the ends of V shaped wire.

2. Slip nickel plated clamp on the ball end of the stand.

3. Insert lamp socket between the two halves of the clamp and tighten screw.

4. To adjust stand hold base with one hand and move socket up or down with other hand. The photograph on this page shows how lamp and assembled stand look. Now your hands are free for experiments.

5. Plug line cord into an outlet. Use only 110-120 volt, AC, 50-60 cycles. Do *not* operate ultra-violet lamp on DC or 220 volts.

6. Avoid dropping or rough handling of ultra-violet black light since it is made of special glass which will not take rough treatment.

The black-light lamp in your kit will let you see the invisible. It will help you produce the phenomenon known as fluorescence. What is this phenomenon which causes inks, paints, crayons, minerals, etc., to glow in beautiful, living colors? To explain this we must first talk about light.

What is light? Light is energy—one form of energy, like sound, electricity and heat.

Light moves in waves of energy, each wave having a measurable length. The unit of measurement of wavelengths is the angstrom. One angstrom unit (abbreviated a.u.) equals four billionths of an inch.

The human eye can see some of the light from the sun. But some light from the sun is invisible. We can't see it because its wavelengths are either too small or too large for us to "see".

We can see light which has wavelengths of from 3800 a.u. to 8000 a.u. This is called the visible spectrum, which can be separated into different colors. The longest wavelengths are red, then orange, yellow, green, blue and finally violet.

Wavelengths shorter than violet are called ultra-violet because they are beyond the violet and can't be seen by the human eye.

Ultra-violet has long, medium and short waves too. Shortwave ultra-violet (also called far ultra-violet) is mostly used in chemical analysis and for killing bacteria. Medium wave ultra-violet (also called middle ultra-violet) produces sunburns and tans. Longwave ultra-violet, (also called near ultra-violet, but mostly referred to as black light) is completely harmless to eyes and skin and produces the phenomenon of fluorescence in over 3000 substances.

This is how it works. You all know that every substance is composed of millions and millions of tiny atoms. The center of the atom is the nucleus, and orbiting around the nucleus are the electrons. When the invisible rays of the black light hit one of these atoms, let us say the atoms of the paint in this kit, the energy of the rays is absorbed by the electrons. The electrons then move around violently, and as they slow down, they release this energy in longer wavelengths which appear to us in colors, according to the specific material activated.

Therefore, every little drop of fluorescing paint or mineral is like a tiny little bulb emitting its own special color of light. As soon as the black-light rays are turned off, the substance stops glowing. All this takes place in an instant, of course, and this is known as the phenomenon of fluorescence.

INTRODUCTION

When you open your ultraviolet kit you will notice that it contains a special bulb, socket and cord set, adjustable lamp stand, bottles of "invisible" paint and invisible ink, an experiment box filled with different materials, fluorescent minerals, invisible fluorescent crayon, brushes and a pen. These materials will help you perform many fascinating experiments, and in so doing help you to learn something about the growing field of ultra-violet fluorescence in science.

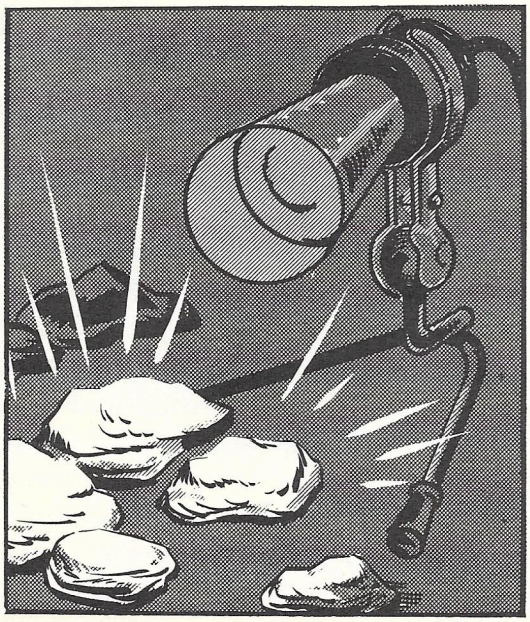
The special bulb is an ultra-violet black light lamp. It is filled with rare gases and when plugged into an electric circuit gives off a purplish glow and certain invisible rays. These invisible rays are known as near ultra-violet or black-light radiation. They are completely harmless to the eyes and skin. They will help you to produce the phenomenon of fluorescence which is described in the preface.

You will be working with the black-light in all of the following experiments.

ACCUSTOM YOUR EYES TO THE DARK:

In order to see some of the wonderful things under your ultra-violet lamp, it is necessary to work in a darkened room. You should let your eyes get used to the dark for at least a minute and you will be surprised how much more you can see when you do the experiments. Later on we will tell you how to make a viewing box so that you can use your ultra-violet lamp while in a brightly lit room. However, for most experiments that you wish to show to your parents and friends, working in a darkened room is the best method to allow everybody to see what you are doing.

Experiment #1
CAUSING MINERALS TO GLOW:



You will find three specimens of fluorescent rocks in your kit. Take the first one out, marked fluorite. Study the rock. What color is it? Now turn off the white light and shine your ultra-violet lamp on the fluorite. Study the rock again. What color is it glowing? This glow is called fluorescence.

The term "fluorescence" was derived from the name of this mineral.

Repeat this experiment with the other two specimens.

Experiment #2
START YOUR OWN FLUORESCENT MINERAL COLLECTION:

The three fluorescent minerals you now have are examples of fluorescence in nature. There are hundreds of minerals which glow in beautiful colors under the short-wave and longwave ultra-violet light. An extensive list is given in appendix A at the back of the book.

Five minerals besides fluorite, which fluoresce most brilliantly under the black-light lamp in your kit are:

Wernerite: A fluorescent variety of scapolite. It is a calcium silicate. The fluorescent variety is found only in Quebec, Canada and occurs in metamorphic rocks, usually with crystalline limestones. It fluoresces a brilliant yellow.

Willemite: An ore of zinc. The specimens that fluoresce bright green under your black light come from the famous zinc mines at Franklin, New Jersey. Many different varieties of fluorescent willemite can be found in New Jersey, Arizona and New Mexico, but some fluoresce under the short-wave ultra-violet and others under more intense black-light lamps.

Autunite: A secondary ore of uranium, made up mostly of uranium and calcium (a calcium uranate) found mostly in pegmatites (coarse grain granite rocks) and occasionally in sandstone. Usually found as a coating between cracks or layers of other minerals. It fluoresces a brilliant green. If of high purity, it can be commercially mined for its uranium content. Connecticut, New Hampshire, Utah, Washington and many other

states have large amounts of autunite.

Adamite: An ore of zinc. The fluorescent variety is found only in Mapami, Mexico. It is a zinc arsenate and fluoresces green.

Opalite: A secondary mineral, formed over many thousands of years by the effect of heat and boiling water on quartz deposits. It has the same chemical composition as quartz, with a small amount of water added. Fluorescent varieties are found in Mexico and fluoresce green.

Try to get a wide selection of minerals from those locations where fluorescent minerals are known to be. In almost every fair-sized town there is a "rock shop" or dealer in rocks and minerals who could be of help to you.

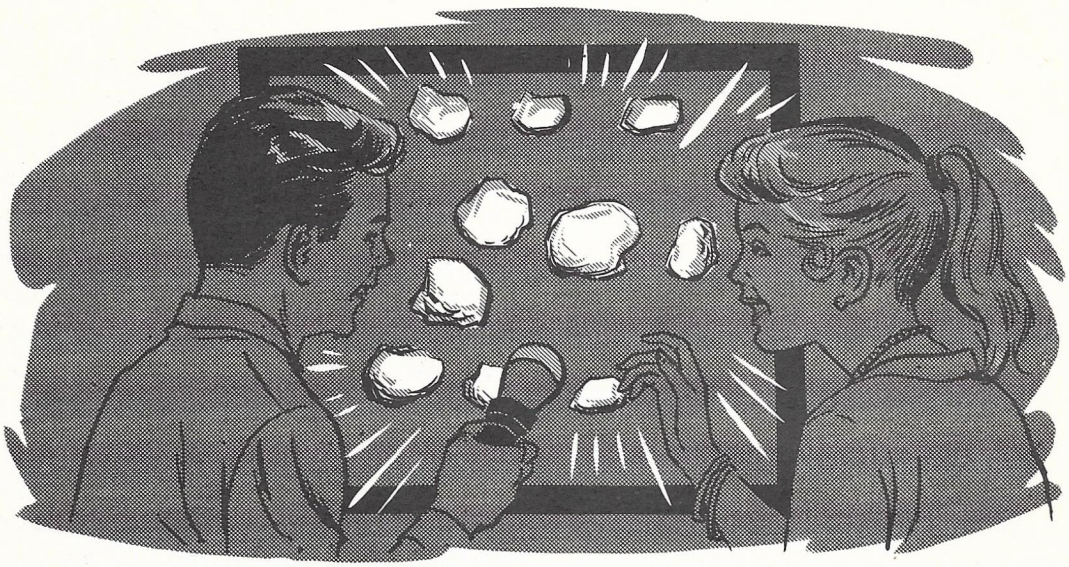
How many different minerals do you find that will fluoresce under ultra-violet light?

FLUORESCENT MINERAL COLLECTING AND PROSPECTING:

Ultra-violet lamps are not only used for collecting fluorescent minerals but also in prospecting for valuable ores and oil.

Although the longwave ultra-violet lamp will fluoresce many minerals, the shortwave lamp activates over 85% of fluorescent minerals and is particularly important in fluorescing certain valuable ores.

Over a hundred million dollars worth of tungsten, uranium and other minerals have been located by their fluorescent response under ultra-violet lamps. But the pleasures of collecting fluorescent minerals are sometimes more rewarding than the search for valuable fluorescent ores. Certainly you have a lot more chance of success in locating beautiful fluorescent specimens of calcite or willemite, then



in finding a commercial deposit of tungsten.

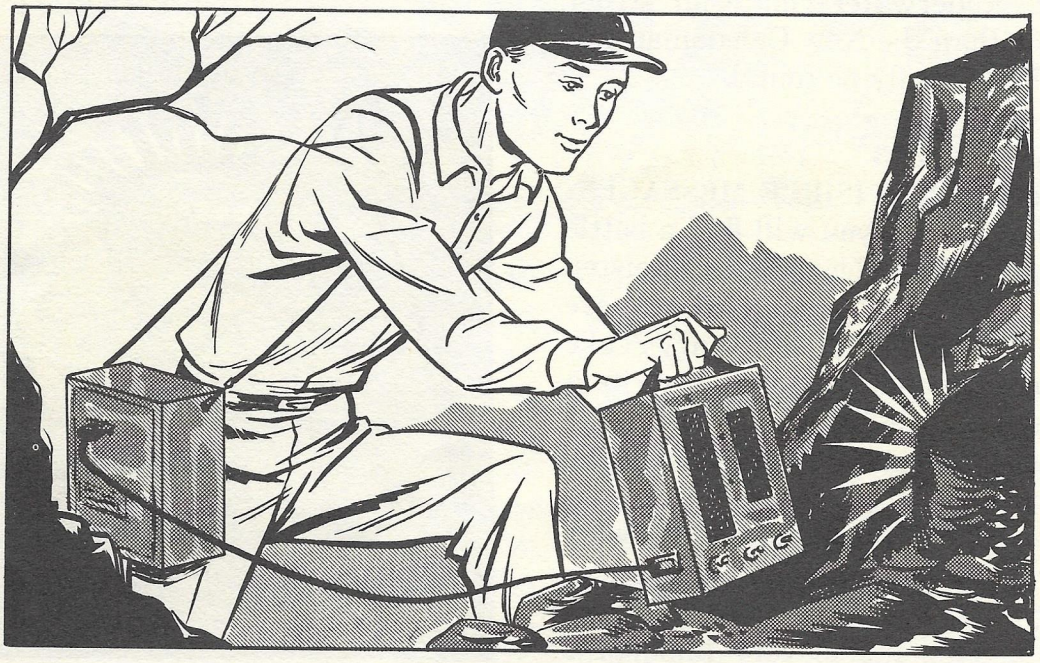
Since natural oil is highly fluorescent under ultra-violet black light, almost all oil companies use battery operated ultra-violet lamps when digging for oil. When the drill comes up with a core of rock and sand, the core is inspected for traces of oil or valuable oils.

FLUORESCENCE IN NATURE:

One of the nicest surprises that awaits you is to see drab ordinary rocks or plain wood come to life under the invisible radiation of an ultra-violet lamp. Why do these rocks glow the way they do? In this case, fluorescence is due to the presence of some impurity. The amount of the impurity is so small that it very often cannot be determined exactly. These impurities are called activating agents. For example, calcite normally does not fluoresce, but if there is a very tiny bit of manganese in the calcite, the calcite will fluoresce red. Uranium salt is also an activating agent, but uranium salt causes minerals to fluoresce green.

The list of fluorescent minerals in appendix A was compiled from various published lists and my own observations. It is by no means complete.

The world's center of fluorescent minerals and fluorescent mineral collecting is in Franklin, New Jersey where more than twenty-six different fluorescent minerals can be found. At night, on the Franklin dumps, walking with a portable black light shining on the ground



is like walking in a fairyland of colored lights. I have indicated Franklin, New Jersey minerals with an asterisk (*).

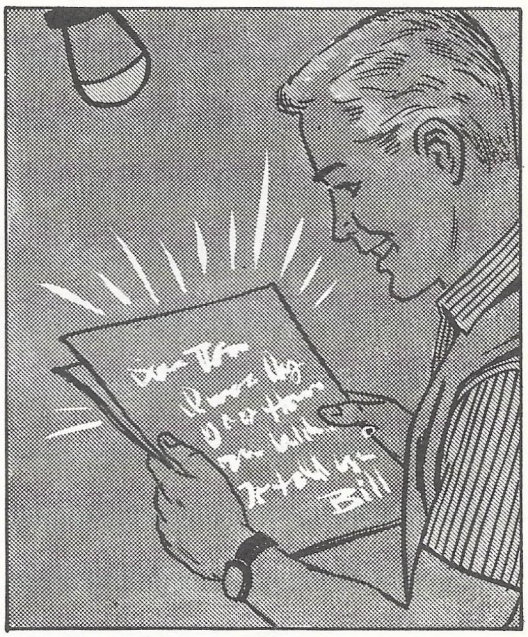
FLUORESCENT DEEP SEA CORAL:

One of the most fantastic examples of fluorescence in nature is that of deep sea coral found in New Caledonia. The fluorescent responses are in vivid reds, greens, yellows, blues, the full range of the spectrum. The exciting source for the deep sea coral was filtered ultra-violet. By far the most wondrous photograph of its kind was that of the Noumea Collection of deep sea coral which appeared in the July 20, 1959 edition of Life Magazine. The photograph occupied the two-page center spread. It is very likely that fluorescent coral and underwater material from other than the New Caledonia area will eventually be found.

Experiment #3

WRITING INVISIBLE MESSAGES:

In your kit you will find a bottle filled with a clear liquid. Moisten the tip of the penpoint to remove the thin film of oil. Wipe dry. Take a piece of plain paper and write a message to a friend. Be sure that you write under the ultra-violet lamp so that you can see what you are writing. You are writing with invisible fluorescent ink which can only be seen under ultra-violet light. This ink is very important commercially. It is used, for example, to identify shirts in laundries and also for invisible coding of cartons and industrial products. Where else might you use invisible ink in industry? At home?



Experiment #4
SAFETY PAPER:

In your experiment box you will find a piece of paper, which under the ultra-violet lamp fluoresces in blue-white squares.

What do you think it is used for? Right. It is used as special paper for bank notes, stock certificates, bank checks, etc., and it is very difficult for counterfeiters to duplicate or for erasures to be made on it. It is called safety paper for that reason.

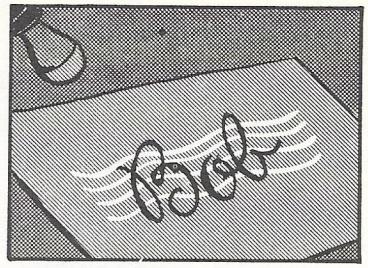
Now, put it under the black light. See the fluorescent material? Write on it with regular ink (don't use a ball-point pen since that is almost impossible to erase). Take some ink eradicator and try to remove the writing from the paper. See what happens?

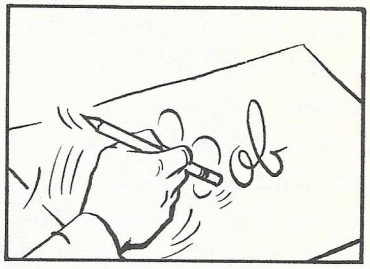
Experiment #5
MAKE YOUR OWN
SAFETY PAPER

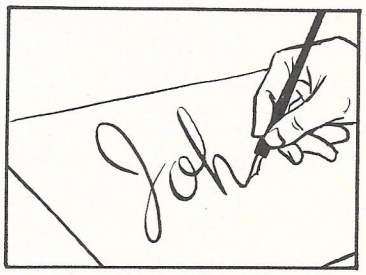
This experiment has three parts to it.

Part #1: Take a piece of paper and write your name on it with ordinary ink. Now erase your name. You will notice, if you are careful, that you can erase your name quite well so that it cannot be seen. Then write a different name in the same place.

Part #2: Now, take a piece of paper and draw wavy lines on this paper with a pencil. Write across these wavy lines with ordinary ink. Erase your signature again.



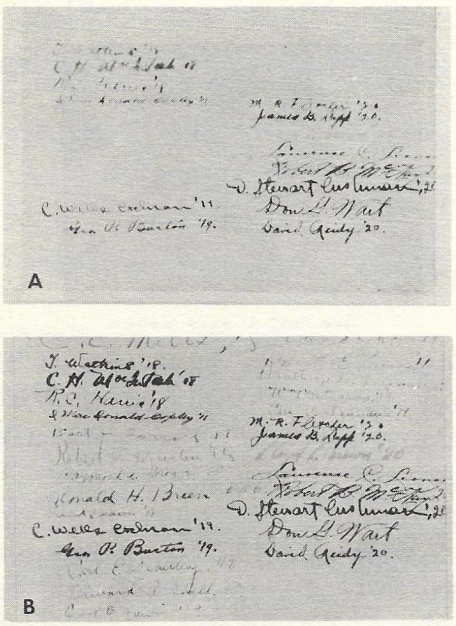




See Part 3, next page

Notice that you have erased the wavy lines as well, so that the erasure becomes very noticeable. However, if you are careful you can repair these wavy lines and then write another name on top of them so that your friends will not be able to tell what name was originally written, or if a name had been erased at all.

Part #3: For the final part of this experiment, take the piece of paper and draw wavy lines on it in pencil. Also draw wavy lines on it in invisible ink, right over the pencil marks. Then write your name in ordinary ink. Now, no matter how careful you were when you erased, you will destroy the pencil line, the ordinary ink line and also the invisible ink line. Unless you had an ultra-violet light you would not know that you had erased the invisible ink line. If you wanted to change the signature, you would repair the pencil lines and write a new name on the paper. However, if you examined this paper under the ultra-violet light, the erased section would immediately become noticeable. You have made safety paper.



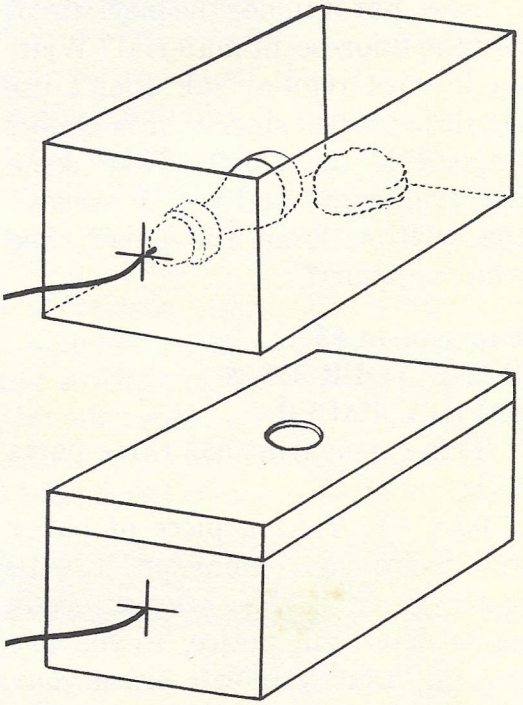
Writing which has faded with age can often be revealed under rays of high-intensity ultra-violet lamp.

How many other applications for safety paper can you think of?

Experiment #6

A FLUORESCENT VIEWING BOX:

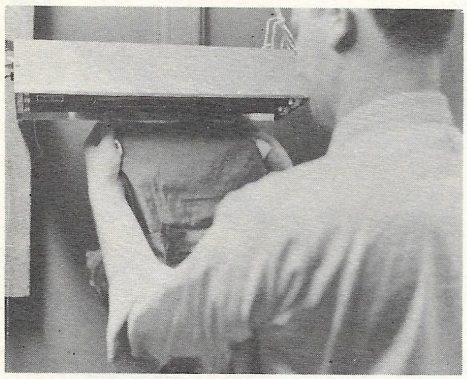
Now that you have learned some of the fundamentals of ultra-violet techniques, you probably will want to go searching around the house for other fluorescent materials and perhaps will want to examine these materials in the daytime when it is not possible to completely darken the room. What you will need now is a fluorescent viewing box.



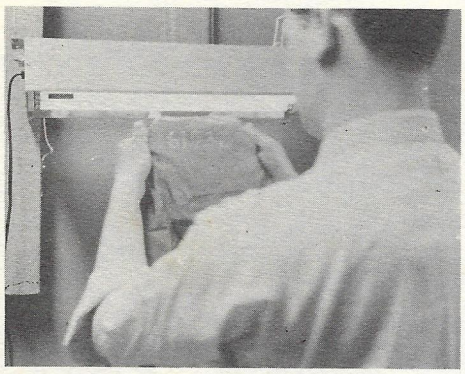
First, get a cardboard carton about the size of a shoe box. Cut a cross slot in the end of the box as shown in the drawing. Set your lamp in the box and push the plug through the hole, pressing the cardboard back around the cord so that it is as light-tight as possible.

Now take the cover and cut a small hole in it about the size of a quarter so that you can peek through it with one eye. Plug in your cord, place your specimen in the box, put the cover on the box and examine the specimen through the peephole.

Many laboratories use similar boxes, on a larger scale of course, for fluorescence analysis in a brightly lit laboratory. They call them portable dark rooms.



(Photo courtesy of Textile Industries Magazine, March 1956)



Invisible ink used on textiles for invisible coding, shows up brilliantly under black light.

Experiment #7
AROUND THE HOUSE WITH ULTRA-VIOLET BLACK LIGHT:

Let's take a tour of your house and see what can be revealed with your ultra-violet lamp.

Your mother's lipstick for example. Examine it carefully in its case. Put some on a piece of paper. Does it glow?

Why not try vaseline, sewing machine oil, waxes, etc. Many of these items are fluorescent under ultra-violet black light.

Detergents are an excellent choice. One of the most interesting is Spic and Span. Another is Tide. Why do they fluoresce the way they do? And while you are experimenting with Tide, shine the black light on the package it came in. What sort of fluorescence is this?

Also don't forget to check plastic materials of all kinds, such as bottle caps and buttons.

Experiment #8
PAPER THAT'S WHITER THAN WHITE:

Take the two sheets of white paper which you will find in your experiment box and examine them under regular light. Do you see any difference? Now take these two sheets and examine them under your ultra-violet light. What do you see? The bright paper contains what is known as optical bleach.

You may have noticed while working with the ultra-violet light, that your shirt and your handkerchief fluoresce with a bluish-white color. This is because the manufacturer of these materials used optical bleach when making the

fabric and your mother probably uses a soap or detergent that contains optical bleach. This causes the clothes to become what the advertisements call "whiter than white".

Take some other paper around the house and examine it under your ultra-violet light. You will probably find that your mother's good stationary fluoresces while ordinary newspaper and inexpensive magazine papers do not fluoresce.

Experiment #9
A LITTLE MATTER OF CONTRAST:

Write your name with invisible ink on the white paper containing the optical bleach and also on the white paper which does not have the optical bleach.

Look at both papers under your ultra-violet lamp. What has happened to one of the signatures? Why do you think this is so?

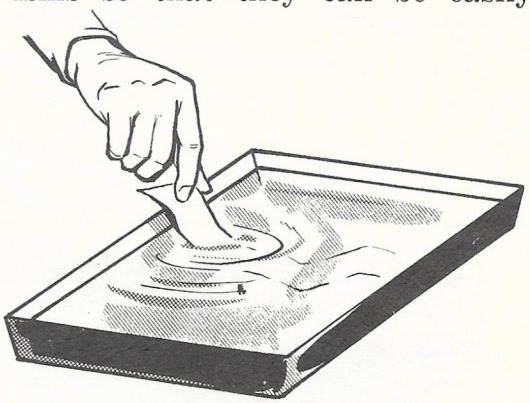
Experiment #10
MAKING YOUR OWN FLUORESCENT DYES:

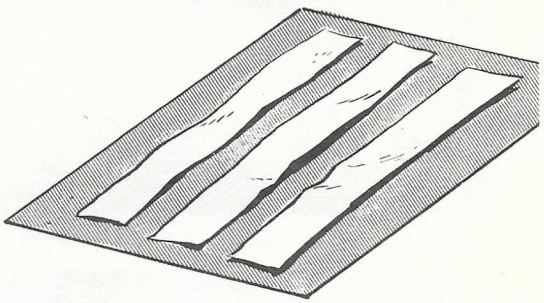
Take any one of the fluorescent paints and dilute it with water until it is as thin as ink. Put it in a shallow tray. Now take a plain strip of white ribbon, thread or cloth and set it into the tray to soak.

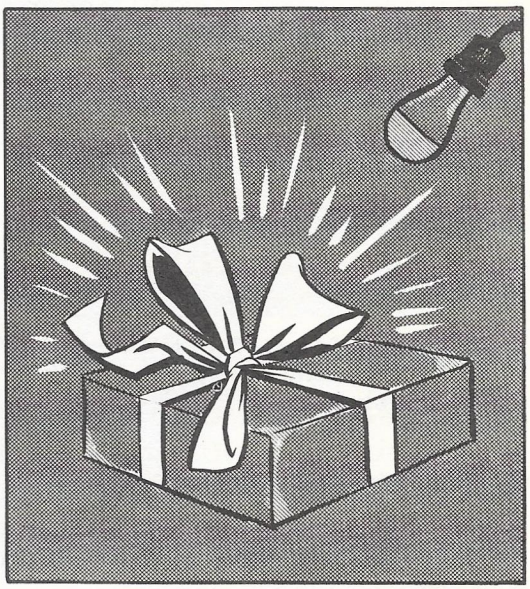
After about 10 or 15 minutes, remove and let dry on several layers of newspaper. You now have a fluorescent dyed material.

Fluorescent dyes are used for many important industrial, commercial and laboratory applications.

Fluorescent dyes are used to stain certain kinds of microorganisms so that they can be easily







identified under the ultra-violet light. This technique is of the utmost importance in identifying organisms which cause typhoid fever, bubonic plague, diphtheria and many other diseases. We will discuss more of this later on.

Fluorescent dyes, both visible and invisible, are used to make fluorescent fabrics and paper such as the bright fluorescent paper in your experiment box.

These dyes are widely used for coding purposes, for tracing and identification purposes in advanced techniques of laboratory analysis. One of the most important of these techniques is fluorescence chromatography which we will also discuss later on.

Can you think of some interesting applications for fluorescent dyes at home or at school? One example of this would be making a fluorescent fountain or pool by adding dyes to the water. Of course, you would need a much larger black light depending upon the size of the fountain.

Experiment #11
FLUORESCENT OPTICAL BLEACH:

In your experiment box you will find a small plastic bag containing a white powder. Take a small jar or a cup, filled with water. Add enough powder until you see the water fluoresce brilliantly under the black light.

Mix thoroughly until the powder is dissolved. Now take some ordinary grocery string and examine it under the black light. It probably does not fluoresce, but if it does, try to find another piece of string that doesn't.

Soak the string for several minutes in the fluorescing liquid you have prepared. Take it out and let it dry. Examine it under the black light and compare the fluorescent color with that of one of your shirts or handkerchiefs. Your fluorescent optical bleach has made the string "whiter than white". Besides fluorescing under black light the string will appear whiter in ordinary light or sunlight. The reason is that the bleach takes the ultra-violet light that's present in sunlight and changes it to visible light. Actually it is fluorescing a white color.

FLUOROCHEMISTRY:

There are literally hundreds of commercially available chemicals which are fluorescent under filtered ultra-violet. For one of the most complete lists, we refer you to pages 3001 thru 3012 of the Handbook of Chemistry and Physics, 40th Edition, published by The Chemical Rubber Publishing Company. An important commercial use of fluorescent chemicals, is the widespread use of optical bleaches to make garments appear "whiter than white". Most soaps, detergents and bleaches now have optical

bleach incorporated in them. As a result, your shirt or pillow case washed with one of the optical bleach detergents will absorb the ultra-violet radiation from sunlight and appear very white. When you shine the longwave ultra-violet lamp on these garments, you will find they fluoresce a brilliant blue white.

At the same time, you might also find fluorescent code marks on your shirt. These are identifications put on by the laundry in invisible fluorescent ink.

There are a great many chemical tests that are performed under black light. There are tests for the presence of petroleum or for the presence of vitamins. Many poisonous insecticides which are used in spraying farm products must, by law, have a special fluorescent coloring agent added so that under black light the presence of any poisonous residues can be determined.

ULTRA-VIOLET PAPER CHROMATOGRAPHY:

One of the fastest growing fields in chemistry, utilizing the natural fluorescence of many substances, is ultra-violet paper chromatography. This new research method has aided in many of the advances in medicine and public health. The analysis of steroids, nucleic acids, proteins, amino acids, chlorinated organic pesticides, flavin nucleotides and many other have been greatly advanced by this technique.

Paper chromatography is the phenomenon by which soluble substances migrate or move in varying rates, with the movement of a solvent through a filter paper medium. By studying the chromatogram after the movement of the chromatographed substance is complete, the unknown substances that make up the compound can often be identified.

FLUORESCENCE MICROSCOPY:

Here truly, is potentially the most important use of ultra-violet. For several years, doctors of the Communicable Disease Center in Atlanta, Georgia, have been trying to find a better method of identifying microorganisms. The technique developed by them was that of fluorescent antibody reagents to make bacteria and viruses identify themselves with a vivid greenish yellow light when activated by ultra-violet. The C.D.C. investigators have now learned to rapidly identify through fluorescence microscopy, the organism which causes bubonic plague; brucellosis; tularemia; meliodosis; glanders; bacillary dysentery and typhoid fever; infant diarrhea; and diphtheria. The same technique is now being applied to rabies, Rocky Mountain spotted fever, typhus and certain types of encephalitides. (Reference Pfizer Spectrum, Volume VII, #1, January 1959)

Still another technique has been developed at Washington's Walter Reed Army Hospital, which involves the use of fluorescence microscopy and a fluorescent stain to

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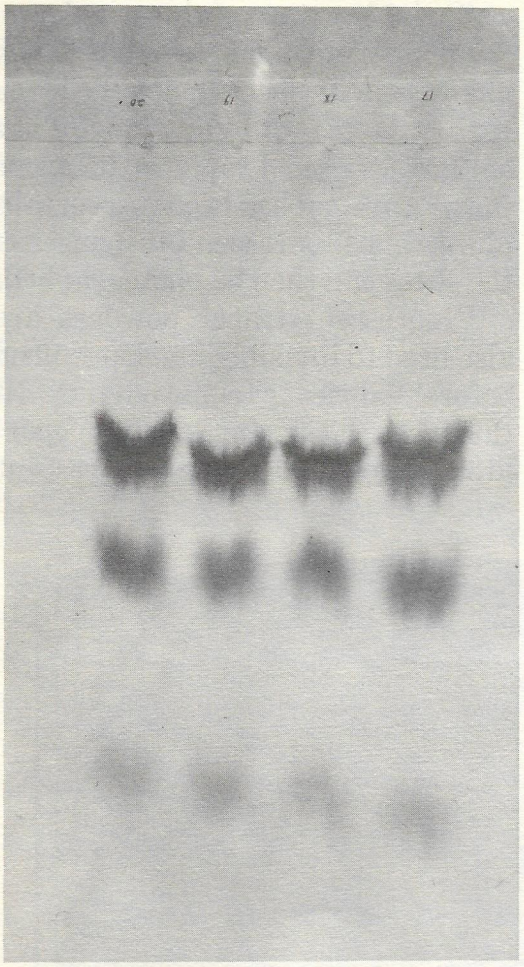
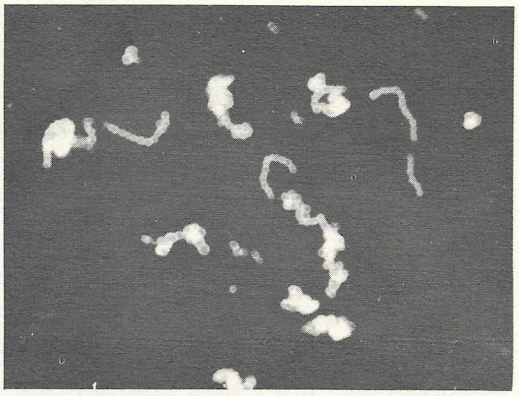


Unknown substances in a compound are readily separated through the new technique of paper chromatography. Chromatogram, viewed under ultra-violet radiation shows otherwise invisible substances.

determine in a matter of minutes, the presence or absence of cancer in human cells. In the not too distant future, your family doctor will be able to determine the presence of cancer in minutes, using fluorescence microscopy, rather than having to wait days for a report from a laboratory. (Time Magazine, May 4, 1959).

(Photo courtesy Dr. Max D. Moody, Communicable Disease Center, Public Health Service)



Photomicrograph shows microorganisms of group A streptococci stained with fluorescent antibody and observed through the microscope under ultra-violet light.

Experiment #12
START A FLUORESCENT WOOD COLLECTION:

Did you know that many woods are fluorescent? In fact, there are thousands of people throughout the country who collect woods of all kinds and find as much interest and pleasure in their hobby as other people do in collecting rocks, stamps, paintings, etc.

But only in the past few years have these collectors learned of the fact that some woods are naturally fluorescent under ultra-violet black light. In appendix B, we have compiled a list of woods which fluoresce under black light. Not all of these will fluoresce under the ultra-violet lamp in your kit, but some of them will. If you go to a lumber yard or out in the woods, try to find as many different specimens of woods as you can. At home you can then check them for fluorescent response.

Some collectors have used these fluorescent woods for beautiful inlaid furniture and marquetry work. In this way they can have one effect in white light and another one under black light.

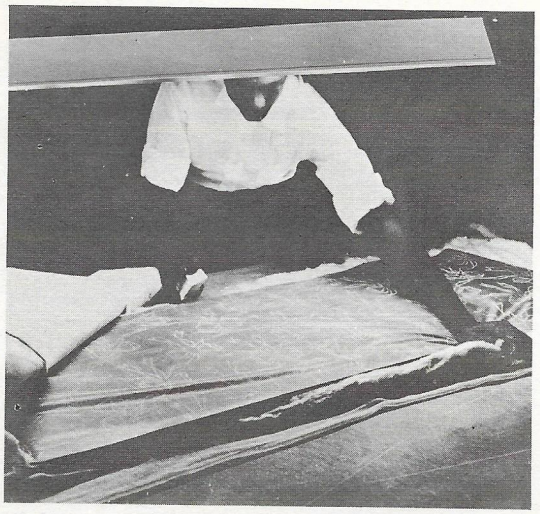
Experiment #13
TRACER POWDER:

In your kit you will find a shallow jar containing a white powder. This is called invisible fluorescent tracing powder.

Sprinkle a little of this powder on the floor and walk through it. Then examine your shoes under the black light. What do you see? This method is used by police to prove that a criminal has been in a certain place. The fluorescent response on the shoes can then be photographed.

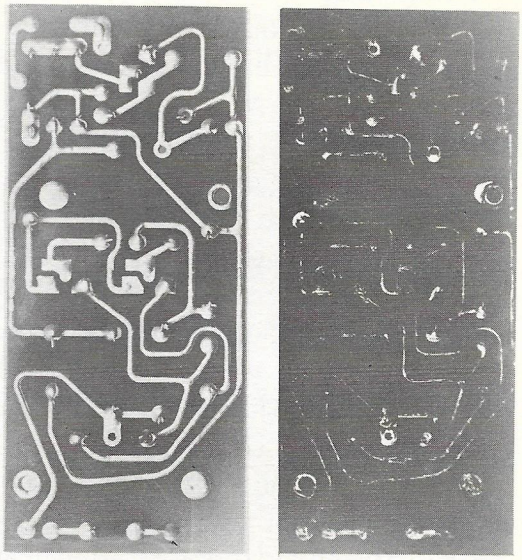
Fluorescent tracer powders are also used to invisibly mark patterns before fabric is embroidered. In this way, the sewing machine operators can follow the fluorescent

patterns, which are invisible in ordinary light. Before invisible tracer powder was used, fabrics had to be cleaned to remove the pattern marking.

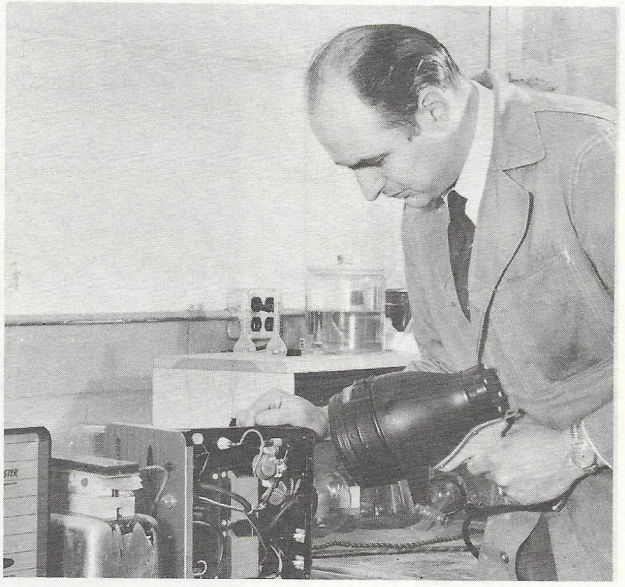


Patterns for embroidery work are marked with invisible tracer powder which can be seen only under black light.

(Electronic Design Magazine, June 1959)



A printed circuit board in normal light and in black light. The bright areas in the black light photograph show fluorescing residual solder flux.



(Electronic Design Magazine, June 1959)

Invisible contaminants on electronic chassis are made visible under black light.

Experiment #14
INVISIBLE MARKING OF MONEY:

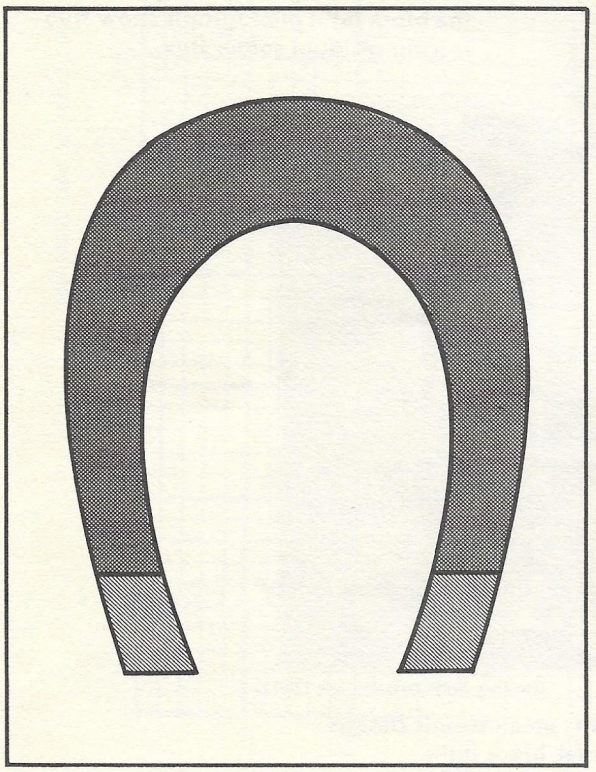
Frequently Police Departments, the F.B.I. and other law enforcement agencies have the need to identify money with an invisible mark which only they could detect. One example of this is when kidnappers or extortionists receive money. In most cases the police will try to mark the money so that it could be later traced and identified. One of the most effective means of doing this is with invisible fluorescent ink. Let us see how this is done.

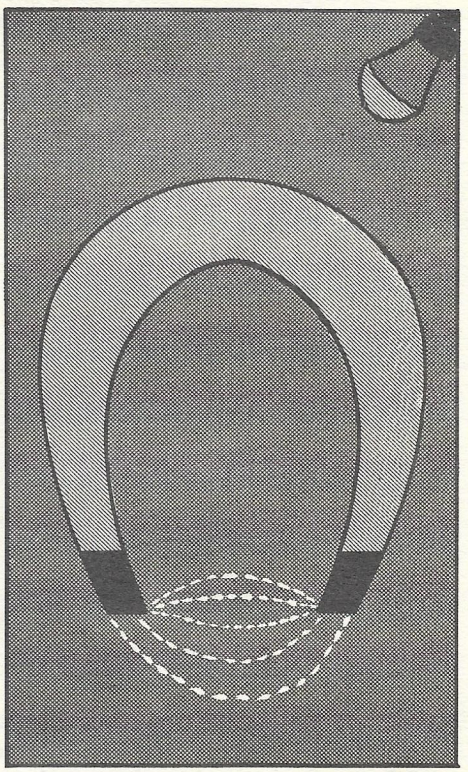
Ask your father to loan you a dollar bill. With the invisible fluorescent ink, put your own identifying mark on the bill. Now when you return the bill to your father you can tell him that you will always be able to identify that particular bill. Show him how the mark appears under the ultra-violet light and disappears when you withdraw the lamp.

Experiment #15
HOW TO SHOW INVISIBLE LINES OF FORCE:

Below you will find a sketch of a magnet. With your invisible crayon draw the lines of force which encompass a magnet.

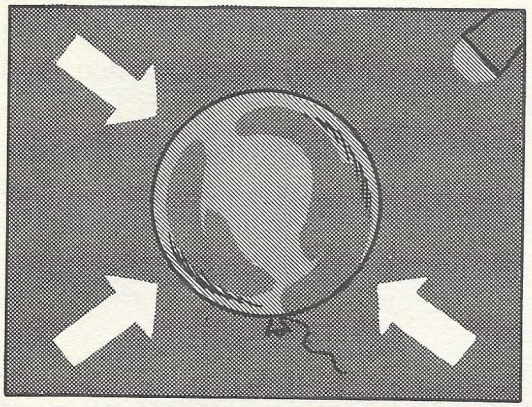
By turning on the ultra-violet lamp the magnetic lines of force become visible. In this way you can illustrate visibly, something whch exists in nature but can't be seen by the eye.

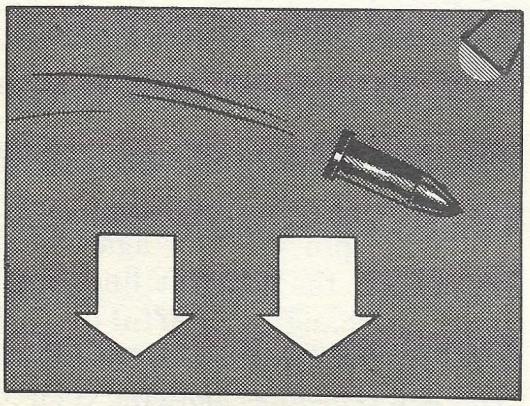


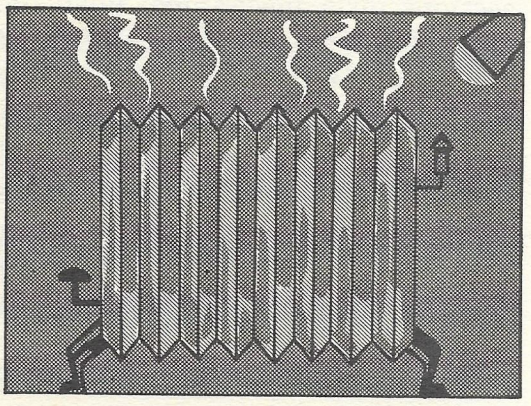


Experiment #16
MAKE YOUR OWN VISUAL TRAINING AIDS:

Using the same principle as shown in experiment #15, try to demonstrate the force of gravity, heat, air pressure, etc.







Army instructor uses fluorescent chalks and black light for graphic visual demonstration.

Experiment #17
A FLUORESCENT STROBOSCOPIC EFFECT—
(Making a Strobo-top).

As you may have already learned in school, electric lights in your home do not burn steadily. Since most homes have alternating current, the electric lights actually flicker on and off 50 to 60 times a second. This is so fast that you can't notice it.

If a skater were twirling on ice at the slow rate of one turn each second, and you opened and closed your eyes once each second just when he was facing you, it would seem that he hadn't made a turn

at all, that he was standing still.

If you opened your eyes a little too late each time, the skater would seem to be turning very, very slowly in the same direction he was actually turning. If you opened your eyes a little too quickly each time, he would seem to be turning slowly in the other direction. Now, instead of opening and closing your eyes, if you simply turn the light on and off, you would produce the same effect.

In order to demonstrate this you can make your own strobo-top.

Take a piece of cardboard, making certain that it is non-fluorescent by checking it under your black light. Cut it into the shape of a circle with a two inch diameter. Using the four colors of fluorescent paints, brush on straight radial lines making sure that each color is represented on the outer rim and inner area of the circle.

Now we have to find a top. (A small mechanical push top with a wooden handle or any small wooden top with a flat head would be fine). Tack or glue the cardboard to the upper surface of the top and spin the top, in a dark room.

Shine the black light on the design and study the fluorescent patterns. You will notice that when the top is spinning at certain speeds it seems to be going in the opposite direction from that which you know the top is spinning. And a moment later, as the rate of spinning changes slightly, it will reverse itself. This happens again and again.

Experiment #18
YOUR EYE-MEMORY
(Making a silk purse out of a sow's ear) :

In the previous experiment you must have noticed something strange and beautiful when you were watching the change in direction of the fluorescent strobo-top. There is an old saying that you can't make a silk purse out of a sow's ear. Well here is an instance where with a little eye-memory you can do just that.

When you drew the straight radial lines on the round piece of cardboard we used for the strobo-top, it certainly didn't look like very much. There wasn't any color in ordinary light, and even under the black light it was just a bunch of colored lines.

But spin the top again and notice how the straight lines turn into ever-changing colorful designs which seem to weave in and out. You will remember noticing colored sections on a mechanical push top change colors and form different patterns as they spun around. This is the same effect, although it is more spectacular in fluorescence under black light. This is because the fluorescent colors are brighter, more intense and there is a greater contrast with the non-fluorescent background.

The reasons the lines are formed

into whirling designs is because your eye remembers the line of color it saw a fraction of a second ago as it sees it again a fraction of a second later in another position.

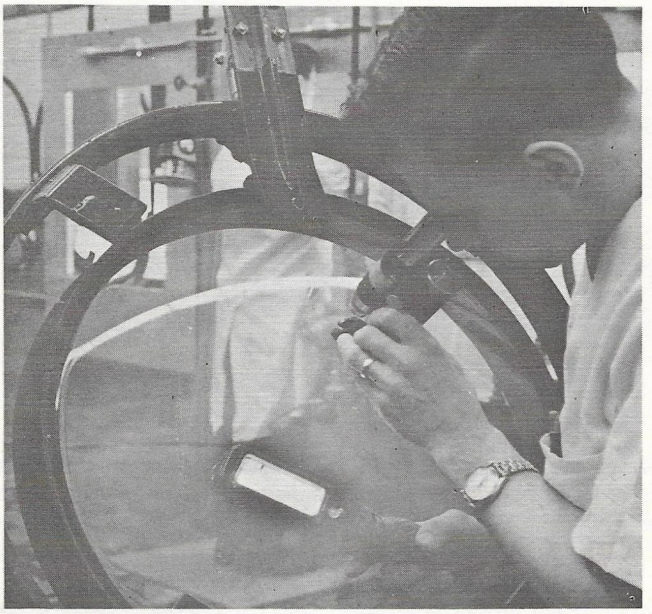
The mind then puts together what the eye has seen and remembered and the result is the mixing of straight lines of color into beautiful, ever-changing patterns.

Experiment #19
MAKING DO IN THE LABORATORY:

Do you enjoy watching television? What would you think if you knew that you are indebted to ordinary rocks for the many hours of entertainment that television gives you. Yes, today we have TV tubes, fluorescent tubes, X-Ray screens and many other electronic equipment which, under the proper activation, can give off light due to the phosphors with which they are coated. But many years ago these phosphors did not exist.

During the early days of experimenting it was necessary for the scientists in the laboratories to obtain their own phosphors from rocks. This is an experiment that you too can try.

Take one of the fluorescent minerals from your kit. Now carefully, with a pin, scrape off or pick out a



(Photo courtesy Sylvania Electric Corp.)

Technician at Sylvania Plant uses black light lamps to check invisible color phosphor dots on TV picture tubes. Blue, green and red phosphor dots respond to longwave or shortwave ultra violet. See cover for photomicrograph of what technician sees.

few of the grains. After you have gathered together a small amount, put them under the ultra-violet light. You will see that they fluoresce.

In the early days the scientists had to carefully obtain these phosphors by crushing to a very tiny size, and under very careful conditions, fluorescent minerals such as those found in your kit. Nowadays, these are prepared in large quantities through improved commercial methods.

Experiment #20
FLUORESCENCE OF JEWELRY UNDER ULTRA-VIOLET LIGHT:

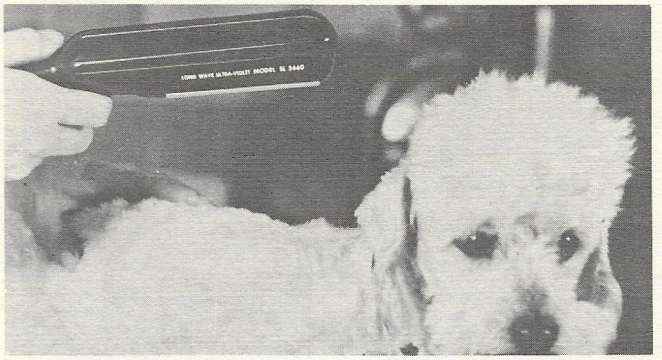
If anyone in your house has an interesting ring, bracelet or other type of jewelry ask them whether you can examine it under the ultra-violet light to see if it fluoresces.

About 5% to 10% of all diamonds will fluoresce under ultra-violet light. In addition, some other gems are fluorescent.

Experiment #21
DETECTING HYDROCARBONS IN MEDICINAL OINTMENTS:

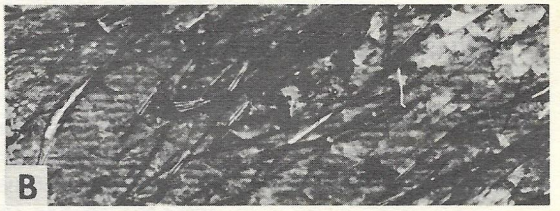
Look over the medicine cabinet in your home and see if you have medicinal ointments such as mentholatum or ungentine.

Take them out and take them into a darkened room where you have your ultra-violet lamp. Shine the lamp on them. You will notice that they fluoresce. This is because



Veterinarian uses black light to fluoresce common ringworm in dogs and cats. Ringworm on human scalp responds the same way.

A. Apparently normal scalp in white light.



B. Under black light, fluorescing hairs and scalp tissue mean ringworm.

they contain hydrocarbons and hydrocarbons are naturally fluorescent.

Many other medicines fluoresce. See how many you can discover and make a list of them. Perhaps your mother or father should be with you while you are doing this.

put a little of this on your door handle. Anybody touching the door knob will get the material on their hands, even though they don't realize it. When you shine the black light on their hands, the hands will fluoresce in green smudges.

The use of invisible fluorescent

New York Fire Commissioner E. F. Cavanagh Jr. looks on as Black Light Eastern Corporation chemist applies invisible fluorescent tracer paste to fire alarm handle.

Experiment #22
MAKE YOUR OWN TRACER PASTE:

For this experiment you will need a small amount of lanolin, or if this is not available, vaseline will do. Mix a little of the tracer powder from your kit, with the lanolin or vaseline. Keep checking under your black light while you stir the powder carefully.

You now have what is known as an invisible tracer paste. You can

tracer pastes by Fire Departments is increasing throughout the country. They coat fire alarm handles with this material, so that if someone turns in a malicious false alarm, they can quickly detect the culprit.

Some cities have cut down the number of malicious false alarms by almost 80%, through the use of this technique.

Experiment #23
DAYLIGHT FLUORESCENT COLORS:

In your experiment box you will find different sheets of paper and plastic. Take out the two sheets of red paper and the sheet of transparent red plastic. Examine these two sheets of red paper under a white light. You will notice that one is brighter than the other.

Now look at these two sheets through the piece of red plastic. What do you see? The bright sheet is coated with a special daylight fluorescent dye. This material takes the ultra-violet light that is present in normal light and converts it to visible light so that it is much more brilliant than regular red paper.

Experiment #24
HOW TO MAKE PAPER DISAPPEAR
(The difference between reflected color and emitted color):

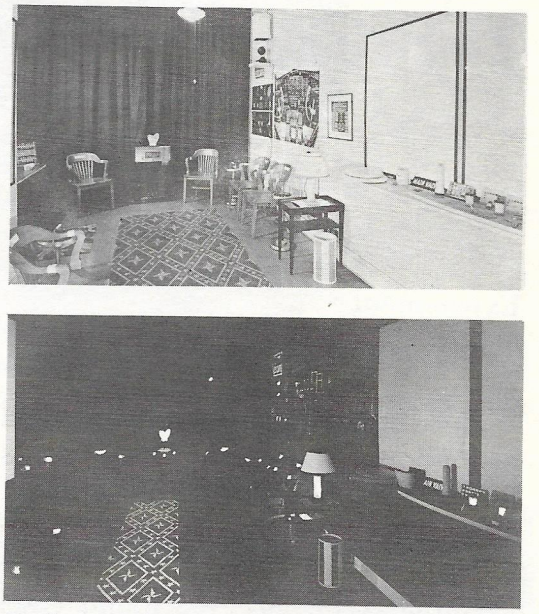
The reason we see color in any non-fluorescent substance is because that substance reflects one of the colors or shades of color which make up white light and sunlight. The non-fluorescent red paper in experiment #23 looks red in white light because it is reflecting the red rays which are present in white light. If there were no light in the room, you could see no color.

Again place the non-fluorescent and fluorescent red paper on the table in front of you. Shine the black light on both of them, while the white light is on. The fluorescent paper is emitting a bright red color, but you can still see the red color that the non-fluorescent paper reflects.

Now, turn off the white light and hold the black light about a foot away from both papers. The non-fluorescent paper will lose its color because there no longer is any white light from which it can reflect color. But the fluorescent paper is more brilliant than ever. This is because it is not reflecting color in visible light, but is absorbing invisible light rays and emitting them in a visible color.

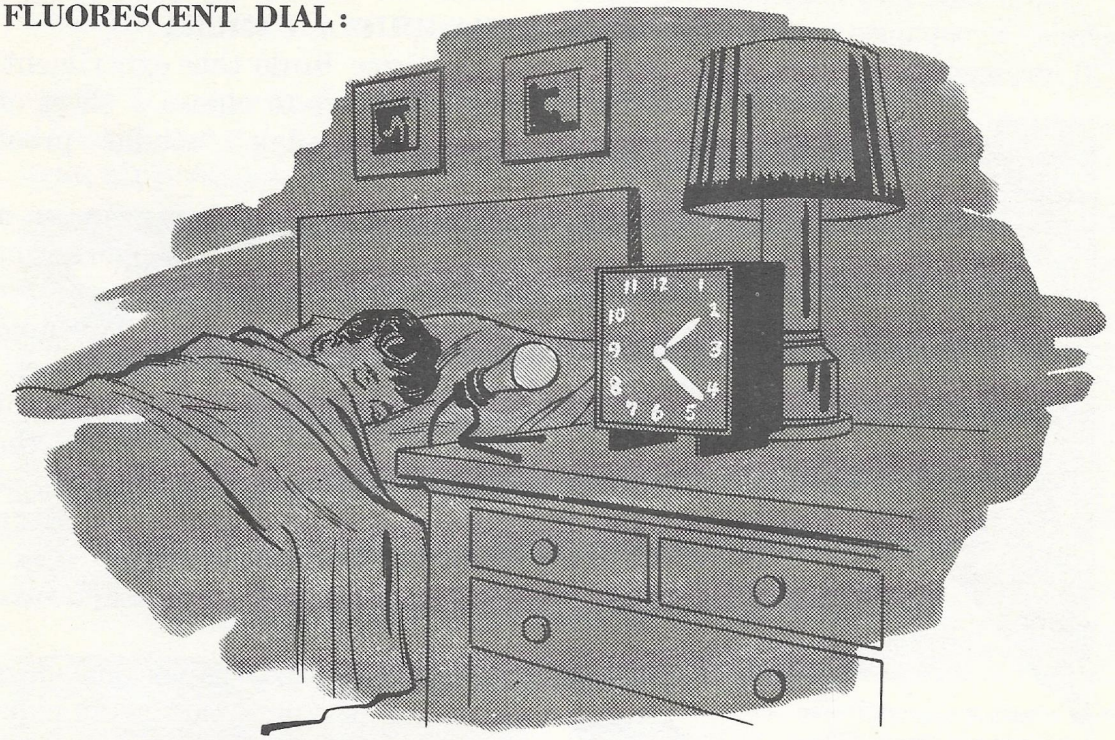
While the black light is still on, view the papers while looking through the red plastic filter. What happens?

(Photos courtesy U.S. Radium Corp.)



Top: Phosphorescent material doesn't glow in white light.
Bottom: In darkness, phosphorescent material which has absorbed the white light, emits it with weird glow.

Experiment #25
ALARM CLOCK WITH FLUORESCENT DIAL:



You have probably seen or heard of an alarm clock which gives off light in the dark. These have been made with a very special paint containing a radioactive substance. However, it is not necessary to use a radioactive substance in order to achieve the same ffect.

If you have an alarm clock with a glass or plastic front you can indicate the numerals by using the invisible fluorescent paint. Then, leave the alarm clock on the night table but with the ultra-violet lamp pointed toward the face. The numerals will glow as long as the ultra-violet lamp is on. The amount of visible light emitted from the lamp also acts as a night light.

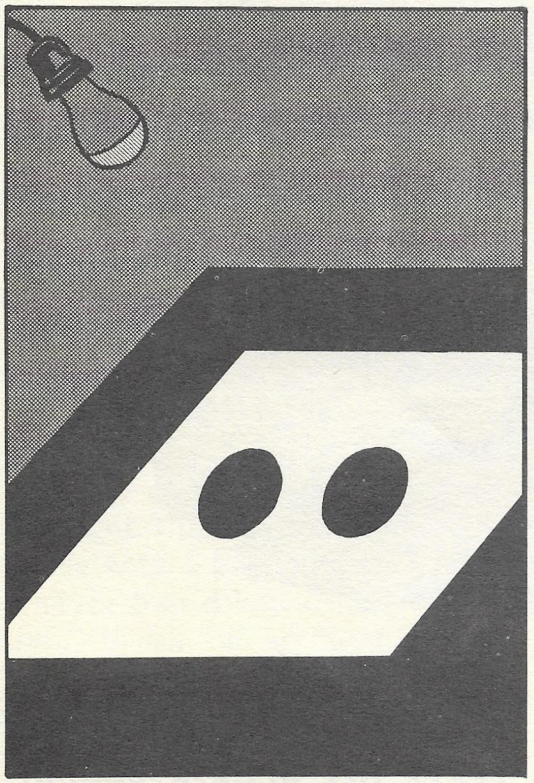
Experiment #26
A PHOSPHORAGRAM—OR HOW PETER PAN MIGHT LEAVE HIS SHADOW BEHIND:

Spread the various sheets of papers and plastics from your experiment box on the table, under a strong white light. Turn out the white light and remain in darkness. What do you notice about one of the materials?

The paper that is still shining brightly with a luminous glow is coated with a special phosphorescent paint.

While still in darkness, shine your black light on the paper. You will notice that it glows under the black light, and when you turn the

black light off it continues to glow. This means that the material is not only phosphorescent but is also fluorescent.



Place a coin on this paper and hold it under the black light. Quickly remove the coin. What do you see? The coin, like Peter Pan, has left its shadow behind. This is what is known as a phosphoragram.

Try the experiment again, but this time, instead of removing the coin completely, just move it to another position on the phosphoragram.

You can repeat this experiment with many variations by using paper cut-outs of animals, ghosts, etc.

Experiment #27
HOW TO TAKE A "PICTURE" WITHOUT A CAMERA:

In order to do this experiment, you will have to obtain a sheet of Eastman Kodak "studio proof paper type F".

Place your phosphoragram on a table with the phosphorescent material face up. Make sure the room is dark. Then place your hand on the phosphoragram and activate the paper with the black-light lamp. You can also turn on the white light for a minute or two so that the phosphoragram stores up a lot of energy.

Now remove your hand and turn off the lights again.

Take the proof paper and place it against the phosphoragram making sure that you have even contact. Allow it to stay that way for approximately one hour. Remove the proof paper and you will find that a permanent photographic print of your hand appears on the proof paper.

Experiment #28
FUN WITH PHOSPHORESCENCE:

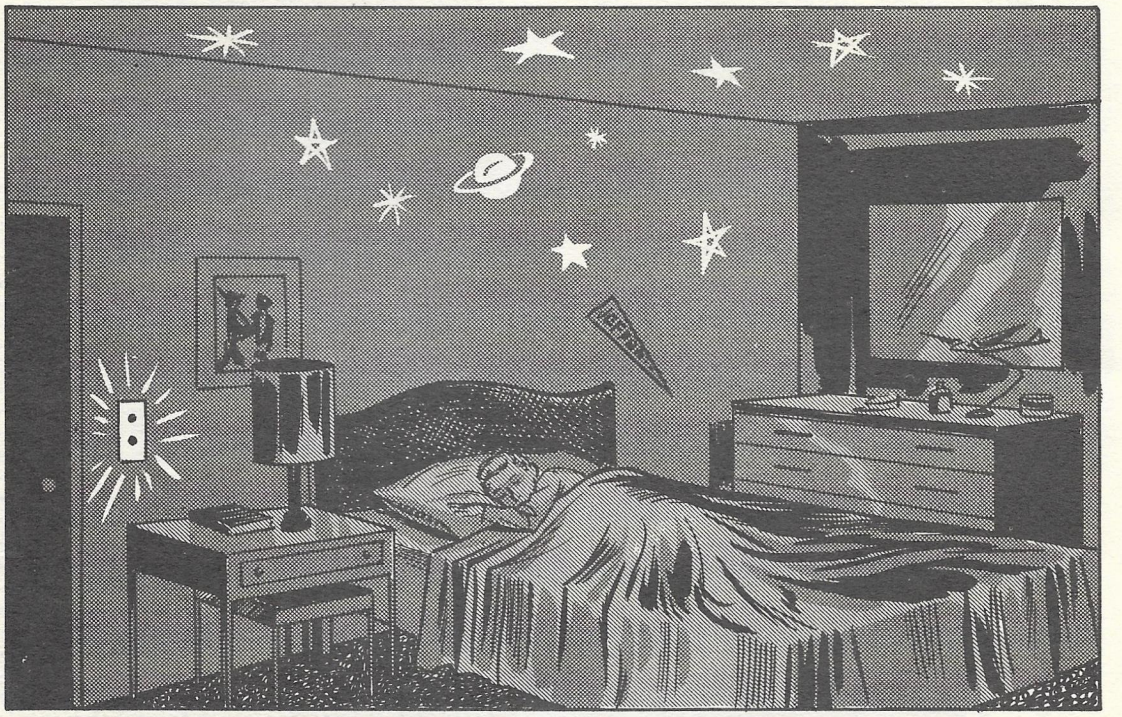
After you have experimented sufficiently with the phosphoragram, you can use this phosphorescent material for other purposes.

For example, you can cut out little stars and paste them on your ceiling and wall. At night, when you turn the white light off, the stars will glow in the dark.

Try using the phosphorescent material around electric switch plates or on the top step of a dark staircase. How many other useful applications can you find for your phosphorescent material?

to completely cover the black light and stand so that you can block out the light instantly when you want to.

Place the phosphorescent material one inch from the black light. Be



Experiment #29

HOW DOES LENGTH OF EXPOSURE TIME EFFECT PHOSPHORESCENT AFTER-GLOW?

For this experiment you must be sure that the phosphorescent material has completely lost its glow. In order to do this, you should put the material in a light-tight box and leave it there over night, or at least for several hours. When you remove it, make sure that you are in a completely darkened room.

You also need a box big enough sure the phosphorescent coating is facing the lamp. Expose the paper to the light for five seconds and then put the box over the black light. How long does the paper continue to glow after the exciting source has been removed? Make a note of the distance, the amount of exposure and the period of after-glow.

Repeat the experiment using the same distance, but changing the exposure time to fifteen seconds; thirty seconds; sixty seconds; ninety seconds.

Experiment #30
DEMONSTRATING VISUALLY THE RESULTS OF EXPERIMENT 29

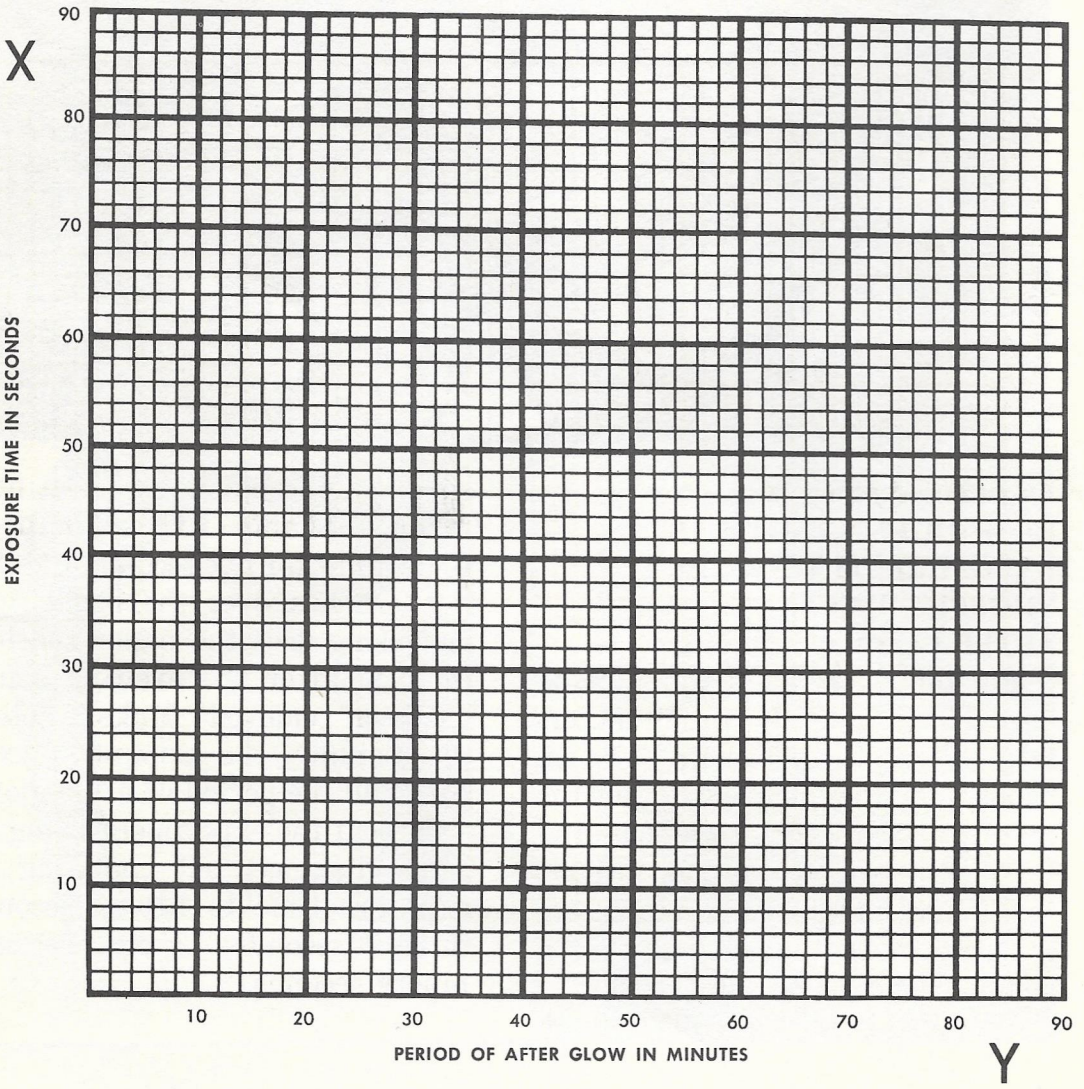
On the graph below you will note that we have represented the exposure times on axis X and the periods of after-glow on axis Y. Put a dot, in the proper location on the graph, in pencil, to represent the period of the phosphorescent response you observed after fifteen seconds exposure; thirty seconds exposure; etc.

Now connect these dots to form a curve.

Experiment #31
HOW DOES THE VARIATION OF DISTANCE AFFECT PHOSPHORESCENT AFTER-GLOW?

The same care you took in Experiment 29 should be used in this experiment.

You now have the data on after-glow after exposure for fifteen

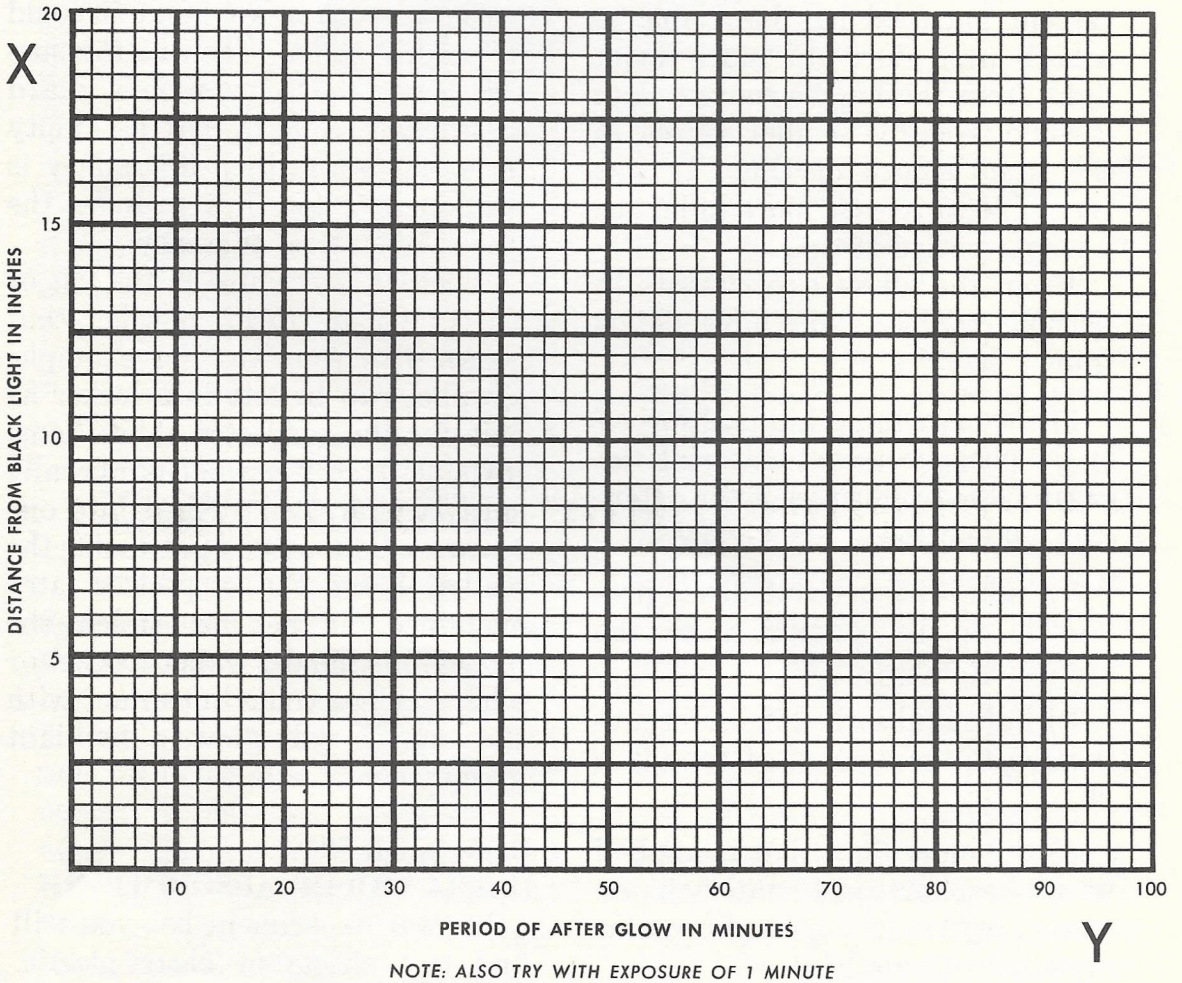


seconds at a distance of one inch. Repeat this experiment keeping the same exposure time but increasing the distance to two inches; four inches; eight inches; sixteen inches. Keep a record of the exposure time, changes of distance and periods of after-glow.

Experiment #32
DEMONSTRATING VISUALLY, RESULTS OF EXPERIMENT 31:

In the following graph you will find the changes in distance represented on axis Y and the periods of after-glow on axis Y. Plot the periods of after-glow in accordance with your recorded observations of the differences due to the increased distances. Start with one inch and then plot the data for two inches; four inches; eight inches; sixteen inches.

Now connect these dots to form a curve. How does the curve differ from that which you obtained in Experiment 30? What does this demonstrate to you?



NOTE: ALSO TRY WITH EXPOSURE OF 1 MINUTE

Experiment #33
HOW DOES PHOSPHORESCENT AFTER-GLOW VARY WITH INCREASE OF LIGHT ABSORPTION?

Place the phosphorescent material next to the black-light lamp for five seconds. Study the brightness of the after-glow in darkness. Now place the phosphorescent material next to a 100-watt incandescent bulb for five seconds. Again study the brightness of the after-glow in darkness.

This shows you that the phosphorescent material has been able to asborb and store up much more light from the bigger source, than it could from the smaller source, in the same length of time. It was then able to release more light, for a longer period of time.

From the above experiments in phosphorescence, you have determined that:

1) the more light that is absorbed by the phosphorescent material, the greater the brightness of the after-glow and period of after-glow.

2) light is absorbed in direct proportion to its proximity to the absorbing object.

3) light is absorbed in direct proportion to the amount of time it is on.

4) the more light that is applied to a phosphorescent material, the more light the phosphorescent material will absorb.

Experiment #34
HOW TO HOOK A FISH WITHOUT A HOOK:

There are many places that have a problem of pilferage and stealing of small items. Gymnasiums, schools, swimming pools and other places where valuables are left in lockers are some examples.

One way to stop the pilferage and track down the thief is to use an ultra-violet lamp and invisible fluorescent ink. A plant or trap is set by carefully marking money with the invisible ink and placing it in a locker in such a way that it could be readily stolen. Then as the suspect leaves the locker room a guard or teacher requests that he empty his pockets and then his money is examined to see if it includes the invisibly marked currency.

Another procedure is the use of the invisible tracer powder that comes with your kit. For example, a wallet can be left in a locker as bait for the suspected thief. Some invisible tracer powder is liberally sprayed and then rubbed into one or two bills that you put inside the wallet. When the suspect is later examined, if he has stolen the money, his hands, wallet, pocket or whatever has come in contact with the money will glow a brilliant green color.

Experiment #35
ULTRA-VIOLET ABSORPTION:

In your experiment box you will find two sheets of clear plastic.

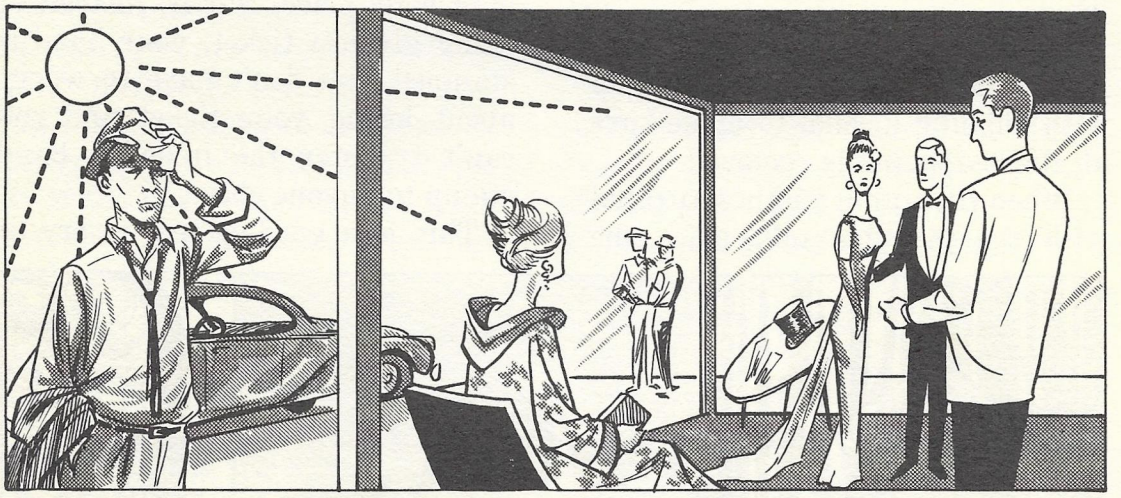
With your fluorescent crayon, make some bright marks on a piece of paper. Now set your black light lamp on the stand about 3 inches from the fluorescent marks.

Take one sheet of the plastic and place it in between the black light and the marks. Now take the other sheet and put that one in front of the lamp. Observe the results, what happened?

coated on clear plastic and other materials and which would completely absorb ultra-violet rays should have some important industrial applications.

One of the earliest uses of the u.v. absorber was as a clear coating on store windows, to stop the harmful ultra-violet rays which caused fading of merchandise.

Even ordinary fluorescent tubes



Why do you think that two apparently similar pieces of plastic could produce such different results? The answer is simple. One piece of plastic has been coated with a clear, transparent ultra-violet absorbing material. This material does not permit any ultra-violet rays to pass through it, so that the fluorescent material is not activated and therefore does not glow.

The use of ultra-violet absorbers in industry and in commerce is comparatively new. But you can imagine that an invisible clear transparent liquid which can be

emit a certain amount of longwave ultra-violet light. Therefore, it was discovered that plastic diffusers which were set in front of the fluorescent tubes to make attractive lighting fixtures for offices and stores, would begin to discolor because of the photochemical effect of the ultra-violet radiation. By coating the plastic diffusers with a clear u.v. absorber on the side close to the fluorescent tube, this discoloration was stopped.

Can you think of other applications for u.v. absorbers? How about sunburn lotion?

Experiment #36
INVISIBLE "PASS-OUT" IDENTIFICATION:

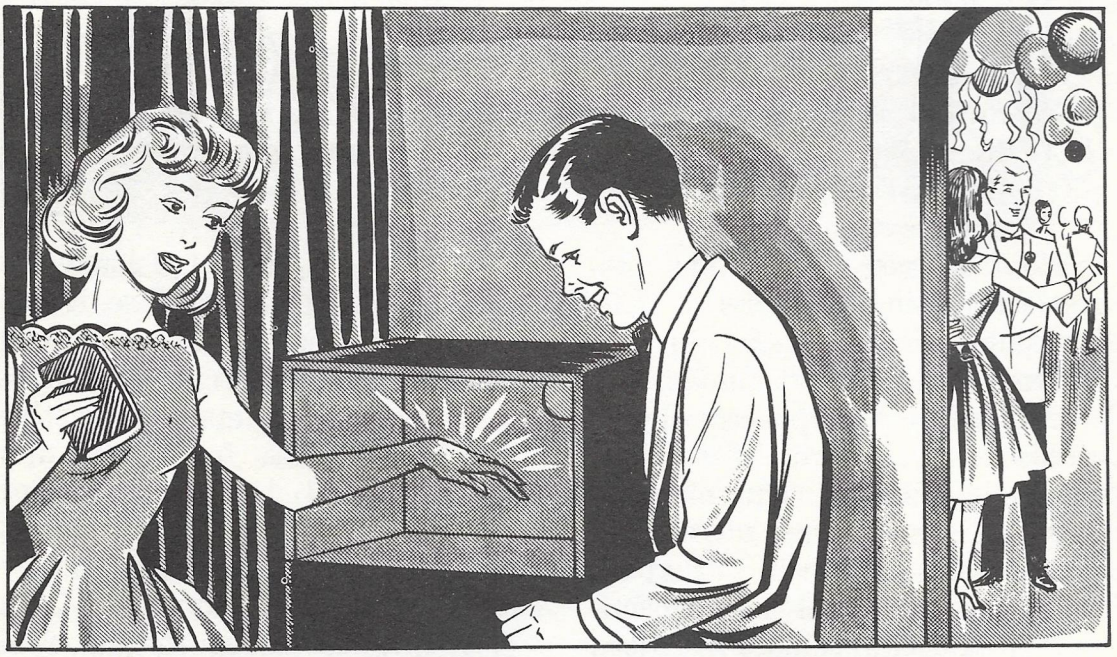
Take some of the invisible ink and put it on a rubber or fabric stamp pad. Make sure that the stamp pad does not have any regular ink in it. If an uninked stamp pad is not available, you can make one by using an empty tin of aspirin and folding some clean cloth or felt inside.

Now you need a rubber stamp. Any kind will do. Clean the stamp with rubbing alcohol to make sure all the visible ink is removed.

When the stamp pad is saturated with the invisible ink, place the rubber stamp on it, and then on the back of your hand. Although nothing can be seen in ordinary light, under your black light, the ink and mark is easily identified.

This is an excellent way to identify people invisibly and without them being able to transfer this identification. For example, if you buy a ticket to a dance and then want to leave for awhile, you have to be given something to identify yourself when you are readmitted. If you are given a ticket, you can lose it, or if you wish, give it (transfer) to someone else who can use it in your place. But if, instead of being given a ticket, your hand is stamped, you don't have to worry about losing your ticket and you can't transfer the invisible hand stamp to anyone else.

This is a good system to try at your next club or school dance. Make sure though that you have a little shadow box set up for the black light so that the mark can be easily seen.



(Photo courtesy Richardson & Robbins Company, Dover, Delaware)

Tiny chicken bones are separated from the meat at chicken canning plant. Black light detects smallest bones by characteristic fluorescent response.

Experiment #37
SEARCHING FOR FLUORESCENCE IN COMMERCIAL PRODUCTS:

Examine a set of ordinary coloring crayons under your black light. Do any of these fluoresce? Often you will find that the yellow, orange, bright red and white crayons have a bright fluorescent response.

Check rubber ballons, plastic bicycle handle grippers, plastic bicycle streamers, nylon or woolen knitting yarn, dime-store ribbons, sewing thread, almost anything which could possibly be fluorescent. When you have collected a great many different fluorescent materials, you will find you can use them effectively in demonstrations.

Experiment #38
FLUORESCENCE AND DARK ADAPTED EYES:

As you know, after you have been in a dark room for a couple of minutes, your eyes become accustomed to the dark and you can see quite well.

In radar rooms and briefing rooms of the Air Force and other military agencies, it is essential that the room be in darkness so that one can see, with clarity, detail on the radarscope. (It's easier to view a television set in darkness than in a brightly lit room and a radarscope has even less contrast than a TV set). The problem arises that a radar operator or viewer may also have to look at printing on controls, consoles, switches or a map. If he

were to turn on the lights his eyes would lose their dark adaptation and he could not see the scope clearly for a while. The solution is to use fluorescent materials which respond to filtered black light which emits very little visible light and does not affect the dark adaptation of the eyes.

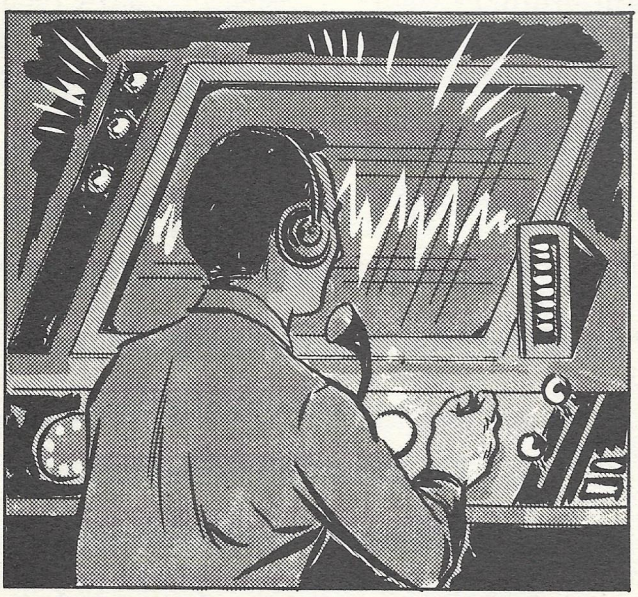
Let us imagine we are sitting at a controls console in a radar room which is in darkness. Set up a piece of cardboard on which you can draw knobs, switches, buttons, etc., all with a regular non-fluorescent crayon or pencil. Print identifications under each of these with non-fluorescent pencil. In darkness you cannot see either the controls or the printing. When you turn the white light on you can see everything, but then you have lost the dark adaptation of your eyes.

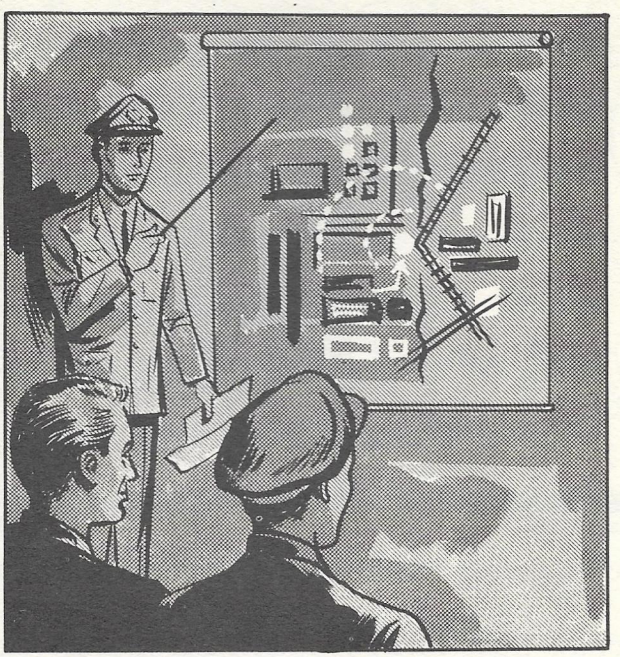
Now go over the controls with your fluorescent crayon, and overprint the letters with fluorescent ink. When you shine your black light on the controls, you can see the switch, knobs, etc., and can also read the identifying words. At the same time your eyes remain dark adapted and you can view the radar screen without difficulty.

Experiment #39
FLUORESCENT MAP PLOTTING IN BRIEFING ROOMS:

Take a map of the United States or the world and stick it on the wall of your room. Let us assume that we are preparing to brief pilots who will be making an important flight at night. Since it is of vital importance that the pilot's eyes be dark adapted for night flying, the briefing is to be done is a darkened room, under black light.

With the fluorescent elastic





string from the experiment box, plot the planned route by sticking a pin into the map and tying the string around the pin. Stretch the string to another point on the map and place another pin there. At each change of direction, place another pin.

Since it is possible that bad weather could make it necessary to change the route, an alternate must be considered. This can be marked with the fluorescent ink.

In flights overseas, near potential enemy territory, it is vital that certain areas or borders be avoided as dangerous. These can be outlined in the fluorescent crayon.

Try using some of the other material in the experiment box to produce different effects.

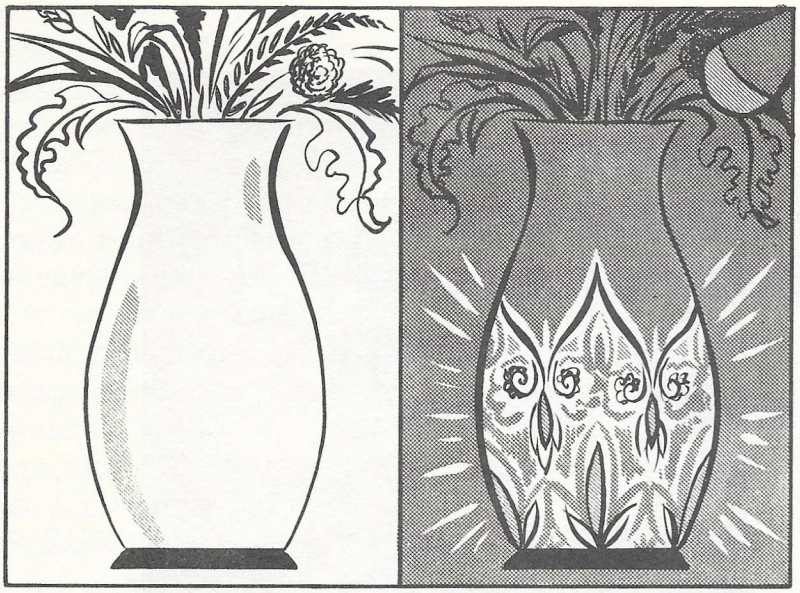
Experiment #40
PAINTING WITH LIGHT:

We say that when we paint with fluorescent paints we are painting with light. We will demonstrate this to you in the following experiment.

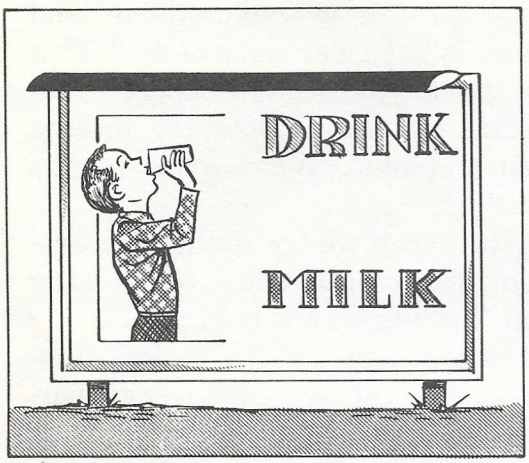
Take ordinary water color paints. Mix two primary colors together, for example, yellow and blue. What color do you see? This is what you would expect from colors in paint. Now try mixing red and blue. What color do you see?

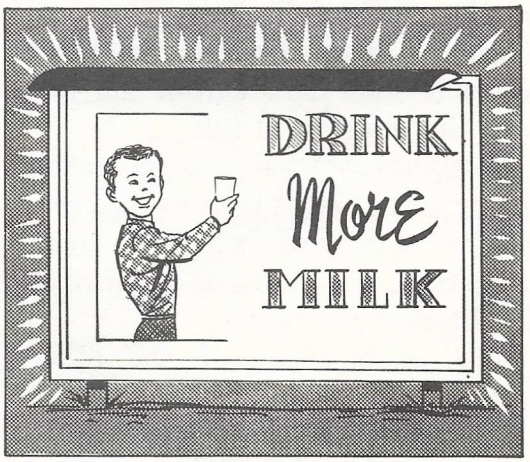
But when we try mixing fluorescent paints the rules for mixing paint colors do not hold true.

Brush some of the yellow fluorescent paint on plain newspaper. About two inches apart, brush some



of the blue fluorescent paint. Then take a flat glass dish and put a small amount of yellow fluorescent paint on it. Add blue fluorescent paint to the yellow until it turns a whitish color under the black light. Brush some of this mixture on the newspaper, in between the other two colors and compare. Repeat the same experiment with fluorescent pink and blue. Why do you think they have a white color instead of green or violet? Right. The fluorescent paint is actually emitting light just as if it were made up of millions of tiny electric colored light bulbs. Instead of following the rules of mixing pigment, it follows the rules of mixing light. When you mix a blue light with a yellow light, you get a white light. Try various experiments with mixing colored lights by using two flashlights and different colored filters.





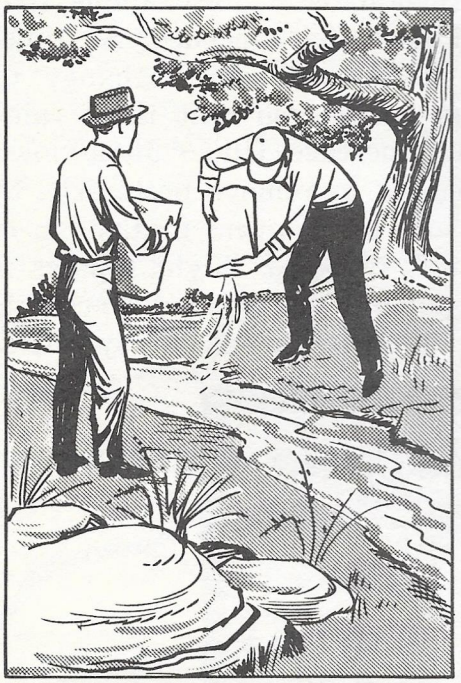
Experiment #41

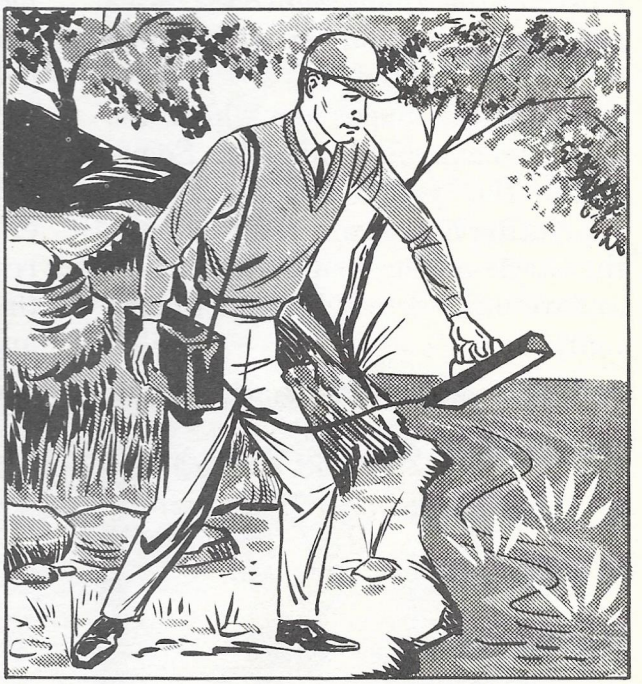
TRACING THE COURSE OF UNDERGROUND RIVERS AND STREAMS:

Do you know that ultra-violet is used by engineers to trace the course of underground rivers?

To demonstrate this, we need a glass or plastic tube about 12 or 15 inches long. Put it in a closed shoe box with one end of the tube sticking out through the left top and the other end of the tube sticking out through the right bottom. You can then imagine that this is an underground river which starts at some isolated spot in the mountains and comes out near your city. The inside of the box represents the various mountains through which the river courses.

Now take a glass full of water and put some of the invisible fluorescent ink inside. Then, turning off the lights and holding your ultra-violet lamp near the tube where the water will run out, you can insert the fluorescent ink solution through the upper top. The solution will run down through the tube and come out at the other end. It would be advisable to have a glass or can to catch the falling water.





Yes, that is how the engineers check the course of the under ground streams. They empty a large quantity of fluorescent dye at a point above ground and then, by checking it at various places where the streams reappear they can tell the connections, and also how fast the stream is moving.

Experiment #42

BLACK LIGHT IN PHILATELY:

If you have a stamp collection, this experiment will not only be fascinating but also important to you as someone interested in philately. If you don't collect stamps, borrow someone's stamp album for these tests.

In darkness, scan all the stamps with the ultra-violet lamp. Because most of the fluorescent responses are very weak, your eyes should be well dark adapted.

Study the paper on which the stamps have been printed. Sometimes the paper stock used in reprinting an issue will differ from the stock of the original printing and would be detectable under black light.

stamps of various kinds, were actually printed with fluorescent inks so that counterfeits could be detected. On the other hand, sometimes the fluorescent characteristic of the ink is accidental. It just happened that in order to get the precise color of ink they wanted the printers used certain materials containing fluorescent chemicals.

Certain stamps might be much more valuable if, for example, they had not been cancelled. At times people have tried to change or forge stamps so that their value would increase. Under ultra-violet, attempts to remove postmarks by erasure or chemical means can be readily detected. Slight repairs to the paper or changing of overprints are likewise revealed by ultra-

Although postmark has apparently been completely removed, under penetrating black light rays, postmark reappears and stamp is revealed as fraudulent.

Study, too, the inks used on the stamps. Some inks will fluoresce brightly, even change color. Many stamps, such as the ration stamps during World War II and tax

violet.

1) Try to find a stamp printed on fluorescent paper and match it with a similar stamp printed on non-fluorescent stock. Try stamps

from Italy, France and Israel.

2) Check stamps from Turkey, Russia, Yugoslavia, Italy for fluorescent overprints.

3) Examine tax stamps, ration stamps and regular issue stamps for fluorescent inks used to identify these stamps.

4) Study your collection for possible erasures, repairs and forgeries.

Serious collectors and professional dealers in stamps use much more powerful ultra-violet lamps in order to detect the low-level fluorescence found in stamps.

GLOSSARY OF TERMS

angstrom unit: (abbreviated a.u.) A unit of length, used to measure wavelengths of light. Approximately 1/4,000,000,000 of an inch.

antibody: When a foreign substance such as bacteria, viruses, foreign proteins, etc., are introduced into the tissues of the body, the tissues react by producing another substance called an antibody.

bioluminescence: Natural luminescence of living organisms. Caused by natural chemical reactions within the organism.

black-light: See longwave ultraviolet.

chemiluminescence: Luminescence caused by chemical reaction.

chromatography: (specifically paper chromatography) A technique used for analyzing chemcals. Soluble substances are allowed to migrate or move, with the movement of a solvent, through a filter paper medium. By studying the chromatogram after the movement of the chromatographed substance is complete, unknown materials that make up the compound can often be identified.

diffusers: Generally made of plastic. They are used under fluorescent tubes to scatter and spread the light in such a way that it appears to radiate evenly from the surface of the diffuser.

electroluminescence: Luminescence caused by exciting phosphors with an electric field.

electronoluminescence or cathodoluminescence: Luminescence caused by electron bombardment.

erythemal effect: An effect produced by radiation of the middle and far ultra-violet. It is commonly referred to as sunburn, on the skin.

fluorescence: A form of luminescence in which light of a visible color is emitted from a substance while it is being excited by light waves of shorter lengths, While it is being excited, it gives off its glow. As soon as the exciting source is removed, it stops glowing. Although fluorescence of

minerals and other substances had been observed for hundreds of years before, it was not until 1852 that Sir George G. Stokes explained the phenomenon. He discovered that fluorescence could be induced in many substances by excitation with ultra-violet light. He named the phenomenon after fluorite, a mineral which glowed under excitation by ultra-violet light.

fluorescence microscopy: A technique for analyzing microscopic substances through their fluorescent response under ultra-violet light.

fluorochemistry: A branch of chemistry relating to the study and use of chemicals which produce a fluorescent response.

hydrocarbon: A class of compounds made up only of hydrogen and carbon. Petroleum is a hydrocarbon.

incandescence: The emission of light caused by the heat of the substance.

infrared: A portion of the optical spectrum. Its wavelengths range from approximately 8000 a.u. to approximately 1,000,000 a.u. It lies between the visible spectrum and radiowaves.

longwave ultra-violet: A part of the ultra-violet spectrum (technically referred to as near ultra-violet but more commonly as black light). Its wavelengths range from approximately 3200 a.u. to approximately 3800 a.u. Its main characteristic is its ability to cause fluoresence in over 3000 substances.

luminescence: The emission of light which is caused by something other than heat.

marquetry: Inlaid work of wood. Very often the wood is mixed with stones, ivory, etc.

medium wave ultra-violet: (technically known as middle ultra-violet). Its wavelengths range from approximately 3200 a.u. down to approximately 2800 a.u. Its most important characteristics are its ability to cause sunburn (erythema) and its ability to cause a tan.

microorganism: A tiny animal or plant visible only under a microscope.

near ultra-violet: See longwave ultra-violet.

phosphoragram: A screen of paper or other material which has been coated with phosphorescent paint or powder.

phosphorescent: When we refer to fluorescence we mean that a fluorescent substance emits light while it is being excited by other light waves. When the exciting source is removed or turned off, the fluorescence stops instantly. In the case of phosphorescence, the phosphorescent substance emits a light after the exciting source has been turned off.

phosphors: Not to be confused with phosphorous or phosphorescent.

Phosphors generally refer to fluorescent powders and substances which are used to make fluorescent paints and coatings such as used in fluorescent tubes and television tubes.

photochemical effect: An effect produced by the chemical action of light on a substance.

photoluminescence: Luminescence caused by ultra-violet or other light rays.

reagent: Any chemical agent.

roentgenoluminescence or radioluminescence: Luminescence caused by X-ray or gamma rays.

shortwave ultra-violet: One part of the ultra-violet spectrum (technically referred to as far ultra-violet). Its range is from approximately 400 a.u. to approximately 2800 a.u. Best known characteristics are its ability to sterilize and kill bacteria, its use in chemical analysis and its abilty to fluoresce many minerals.

ultra-violet: An invisible part of the optical spectrum. Its wavelengths range from approximately 3800 a.u. to approximately 400 a.u. It lies between the wavelengths of visible light and X-rays.

Woods light: This is the same as longwave ultra-violet. In 1903 R. W. Woods developed a special filter which allowed longwave ultra-violet light to pass through, but blocked most of the visible light. The term Woods light is mostly used in the medical field.

THE OPTICAL SPECTRUM:

As we mentioned in the beginning of this book, light is a form of energy. Light which originates from the sun, comes to us in a form of waves of radiation of different lengths. We separate the spectrum bands according to the length of the waves, and call it the optical spectrum.

At one end of the spectrum is the ultra-violet. At the other end is the infrared and in-between we have the visible light.

The ultra-violet section of the spectrum can be divided into three main parts; the short wavelengths (far u.v), the medium wavelengths (middle u.v.) and the long wavelengths (near u.v.).

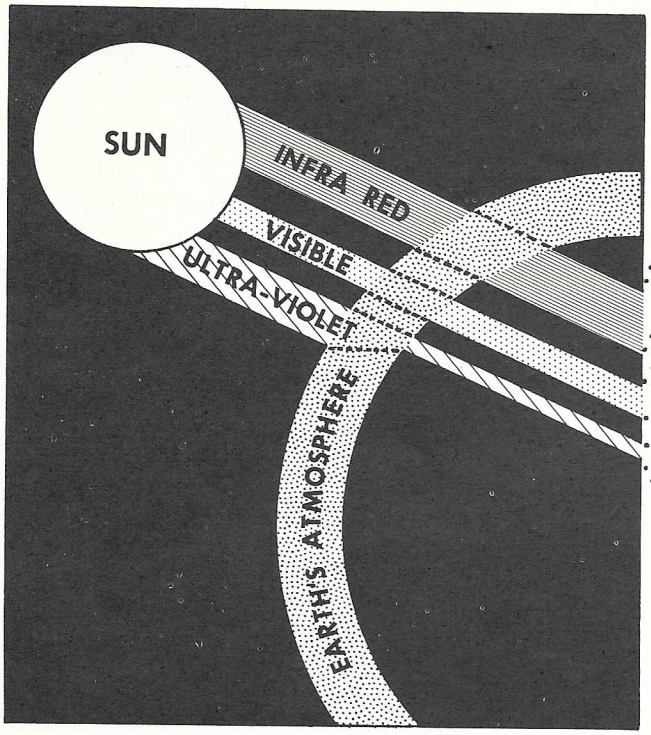
The short wave rays and medium wave rays can cause a burn to the eyes and skin. While the sun emits short wave rays, they are absorbed in the atmosphere and can only be reproduced on the earth by an artificial light source. The medium wave rays reach the earth and are best known for producing sunburn (the erythemal effect) and tanning.

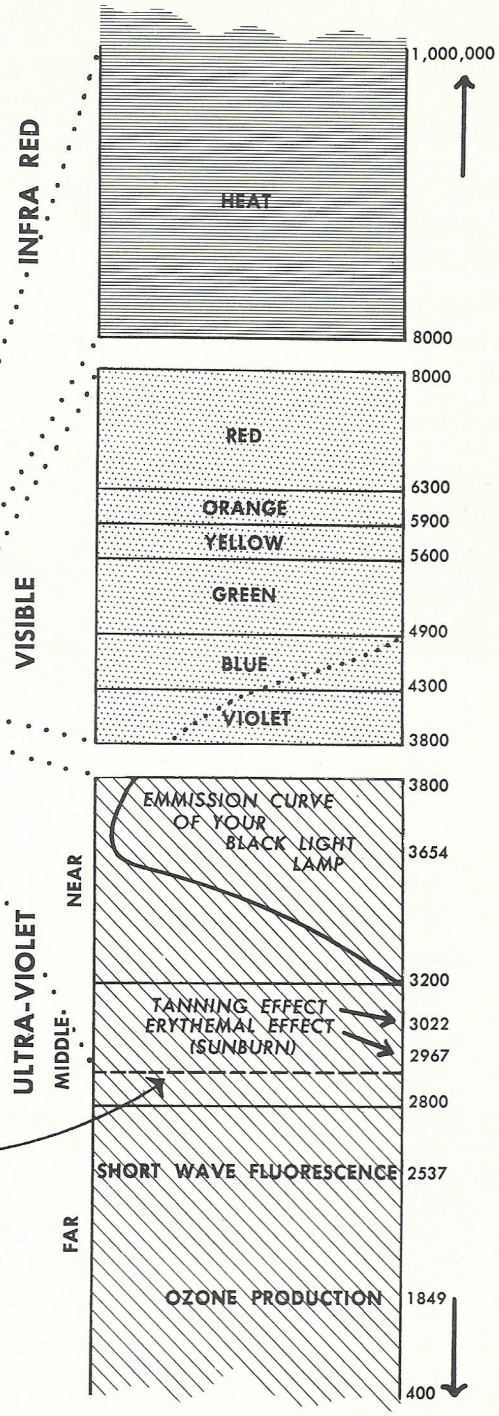
Long wave rays come for the sun, pass through the atmosphere and reach the earth. They are not injurious to either the eyes or the skin since they do not contain any of the wavelengths which produce the erythemal effect.

Below you will find a simplified drawing of a portion of light irradiated by the sun, the optical spectrum.

SEE CHART ON NEXT PAGE

the optical spectrum





ON EARTH ULTRA-VIOLET RADIATION BELOW 2900 A.U. IS ONLY MAN-MADE

NOTE: *ALL FIGURES REFER TO ANGSTROM UNITS, THE UNIT MEASUREMENT OF LIGHT WAVELENGTHS. 1 ANGSTROM UNIT = 1/4,000,000,000 OF AN INCH.*

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APPENDIX A – LIST OF FLUORESCENT MINERALS

MINERAL	LOCATION	FLUORESCENCE	PHOSPHORESCENCE
Adamite	Mapimi, Mexico	Bright Green	
Agate	Goldfield, Nevada	Yellow Green	
	Minas, Brazil	Grass Green	
	Panama Canal	Green	
	San Diego, Calif.	Light & Dark Green	
	Sweetwater, Wyoming	Green	
Albite	Amelia Court House, Virginia	Pale Golden Brown	
	Bedford, New York	Golden Brown	
	Branchville, Conn.	Pale Golden Brown	
	Newry, Maine	Pale Orange	
	St. Gothard, Switzerland	Pale Golden Brown	
Aluminite	Saxony, Germany	White	
Alunite	Marysville, Utah	Grayish White	
Amazonstone	New York & Virginia	Pale Grayish-Green	
Amber	Texas	Yellow	
	Prussia	Yellow Green	
Amethyst	North Carolina & Madagascar	Deep Blue	
Angelsite	Black Hills, S. Dakota & Leadhills, Scotland	Yellow	
*Anorthite	Franklin, New Jersey	Blue	
Apatite	Bohemia	White	
	Hull, Quebec, Canada	Yellow	
	Lake Baikal, Siberia	Gray & Blue	
	Ontario, Canada	Dark Green	
Apophyllite	Paterson, New Jersey	Yellowish	
*Aragonite	Balboa, Spain		Pale Blue
	Crede, Colorado		Light Blue
	Crestmore, Calif.	Pale Yellow	White
	Death Valley, Calif.	Light Green	Light Blue
	Franklin, New Jersey	Cream, Red	
	Lovington, N. M.	Bright Red	
	Peekskill, New York		Blue
	Sicily	Pink	
	Vernonia, Oregon	Cream, White	
Autunite	White Mts., New Hamp.	Yellow Green	
	Newry & Bedford, Me.	Yellow Green	
	Mitchell County, N.C.	Yellow Green	
	Hazardville, Conn.	Yellow Green	
*Axinite	Franklin, New Jersey	Red	
*Barite	England		Bluish Green
	Franklin, New Jersey	Cream	
	Palos Verdes, Calif.	Yellowish White	Yellowish White
*Barylite	Franklin, New Jersey	Blue	
Bauxite	Nadine, Georgia		Whitish
Benitoite	San Benito County, California	Deep Brilliant Blue	
Beryl		Varying Shades of Green	
Borax Crystals			Greenish Blue
*Calcite	Bagdad, Arizona	Deep Blue	
	Cumberland, England		Streaks of Red
	Franklin, New Jersey	All Shades of Red	Red
	Deming, New Mexico	Strong Green	
	Granby, Missouri	Light Green	
	Keller, Washington	Light Pink	
	Lower California	Yellow	
	Mt. Hollywood, California	Red, Yellow & Orange	Red, Yellow & Orange
	Nogales, Arizona	Deep Red	
	Pitcher, Oklahoma	Deep Green	
	Renfrew Co., Ont., Can.	Grayish Green	
	Terlingua, Texas	Blue	Blue
	Tri State District	Greenish Yellow	
	Salmon, Idaho	Pink & Orange	
	San Bernardino Mts., California	Blue	
	Western United States	Whitish & Cream	Cream White
*Calcium-Larsenite	Franklin, New Jersey	Bright Yellow	
Calamine	Superior, Arizona	Cream	
Celestite	Clay Center, Ohio		Blue-White
	Gemback, Germany		Blue
*Cerusite	Franklin, New Jersey	Yellowish	
Chalcedony	Aguila, Arizona	Blue Green	
	Barstow, Calif.	Light Green	
	Brown County, Ind.	Olive Green	
	Oberstein, Germany	Deep Green	
	Sweetwater, Wyoming	Yellow Green	
	Tampa Bay, Florida	Green	
*Clinohedrite	Franklin, New Jersey	Orange & Yellow	
Colemanite	Calico Hills & Death Valley, Calif.	White	Blue-White
Copalite	Zanzibar	Green	
*Corundum	Franklin, New Jersey	Red	
Crawfordite	Barstow, Calif.	Various Shades of Green	
Crocoite	Dundas, Tasmania & Ural Mts. of Russia	Dark Brown	
Cuproscheelite	Milford, Utah & Plumas County, Calif.	Yellow	
Curtisite	Skaggs Springs, Cal.	Bright Yellow, Cream & Green	
Dakeite	Wamsutter, Wyoming	Strong Yellow-Green	
Diamond		Pale Blue, Pale Green, Orange & Reddish	
Diaspore	Chester, Mass.	Pale Yellow	
*Diopside	Franklin, New Jersey	Blue	
Dolomite	Bloomington, Indiana	Pale Greenish Gray	
	England	White to Yellow-Green	
	Lake County, Calif.		Blue White
Dumortierite	San Diego County	Gray	
Elaterite	Utah	Brown	Brown

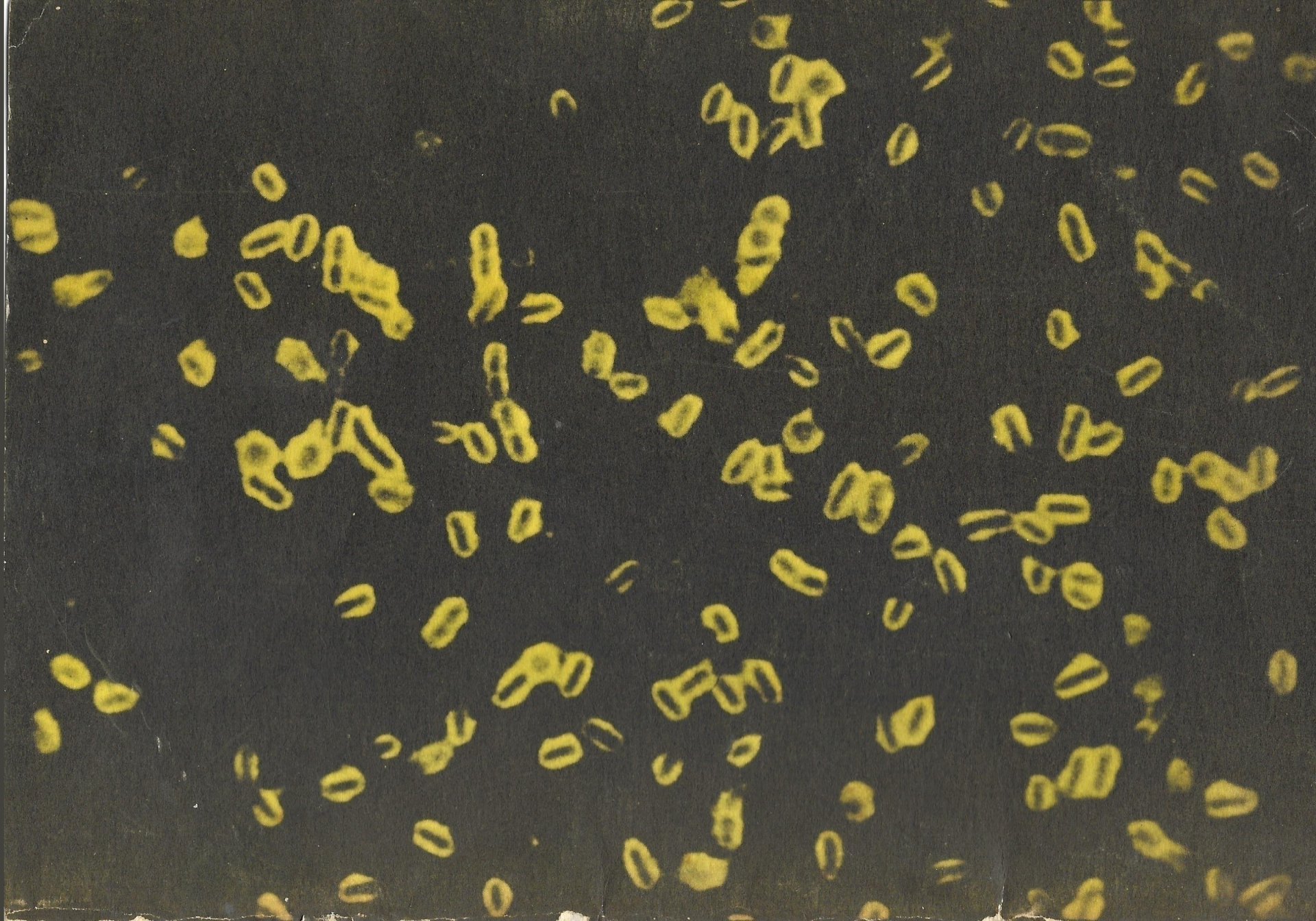
FLUORESCENT MINERALS

MINERAL	LOCATION	FLUORESCENCE	PHOSPHORESCENCE
Emeralds	Muzo, Colombia	Pale Green	
	Minas Geraes, Brazil	Pale Green	
	Emerald Mines, Ural Mts., Russia	Pale Green	
Epsomite	Death Valley, Calif.		Pale Blue
*Fluorite	Alston, England	Blue	Whitish Blue
	Castle Dome, Arizona	Blue	
	Clay Center, Ohio	Bright Cream	Bright Cream
	Franklin, New Jersey	Green	
	Keller, Washington	Blue	
	Trumbull, Conn.		Bluish Green
	Westmoreland, N. H.		Bluish Green
Fluorapatite	Strafford, N. Hamp.	Orange	
Glauberite	Borax Lake, Calif.		Bluish Gray
Gypsum	Saline Lakes, SW U.S.	Green	
	Grand Rapids, Mich.	Deep Green	
Gyrolite	Bohemia	White	White
Hackmanite	Dungannon Township, Ontario, Canada	Apricot-Pink	
Halite	Amboy, Calif.	Red	
	San Diego, Calif.	Brilliant Shades of Red	
	Kansas	Faint Green	
Hanksite	Searles Lake, Calif.		Light Blue
Hemimorphite	Superior, Arizona	Cream	
Hexagonite	Edwards, New York	Red	
Howlite	Lang, Calif.	Brown & Yellow	
Hyalite Opal	Described Under Opal		
Hydromagnesite	Lodi, New Jersey		Light Blue
*Hydrozincite	Franklin, New Jersey	Blue	
	Goodsprings, Nevada	Blue	
	Keeler, Calif.	Blue	
	Northern Utah	Blue	
	Southern Idaho	Blue	
Inyoite	Death Valley, Calif.		Pale White
Kunzite	Pala, Calif.	Pale Yellow to Reddish Yellow	
Lepidolite	Keystone, S. Dakota	Pale Green	
Limestone		Orange, Yellow, Cream, Green or Blue	
Manganapatite	Hazardville, Conn.	Orange	
	St. Marys Lake, B.C.	Orange	
	McCall, Idaho	Orange	
	Valyermo, Calif.	Orange	
*Margarosanite	Franklin, New Jersey	Blue	
Marialite	Ludwig, Nevada	Rose Pink	
Marshite	Broken Hills, New South Wales	Golden Bronze	
Mercury		Not Fluorescent	
Meyerhofferite	Death Valley, Calif.	Blue	Yellow White
*Microcline	Franklin, New Jersey	Blue	
*Norbergite	Franklin, New Jersey	Yellow	
Opal			
Hyalite-Opal	Bagdad, Arizona	Green	
	Barstow, Calif.	Green	
	Beaver, Utah	Green	
	Bishop, Calif.	Green	
	Connell, Washington	Green	
	Fulton, Nevada	Green	
	Lind, Washington	Green	
	Salmon, Idaho	Green	
	Stone Mt., Georgia	Green	
Common Opal	Alpine, Texas	Green	
	Big Fork, Montana	Green	
	Lovington, N.Mexico	Green	
	Virgin Valley, Nevada	Green	
Opalized Wood	Eden Valley, Wyoming	Green	
	Goldfield, Nevada	Green	
	Huntsville, Texas	Green	
Ozocerite	Brazil & Persia	Yellow Brown	
Pearls		Artificial do not	
		Cultured do	
*Pectolite	Franklin, New Jersey	Orange	
	Paterson, New Jersey	Bright Splashes of Orange, Yellow & Light Green	
	Lake County, Calif.	Bright Splashes of Orange, Yellow & Light Green	
Phosgenite	Monte Pone, Sardinia		Brownish Red
*Powellite	Beaver, Utah	Yellow	
	Bishop, Calif.	Yellow	
	Lordsburg, N. Mexico	Yellow	
	Franklin, New Jersey	Yellow	
	Randsburg, Calif.	Yellow	
Priceite	Death Valley, Calif.	Yellowish	
Quartz	Brazil		White
*Rhodonite-Bustamite	Franklin, New Jersey	Red	
Rubellite	Pala, Calif.	Lavender	
	Newry, Maine	Lavender	
Ruby	Siam	Weak Red	
	Burma	Strong Red	
	North Carolina	Strong Red	
Sassolite	Tuscany, Italy	Blue	
Satin Spar	Different Locations	Pale Bluish Green	Pale Bluish Green
*Scapolite	Franklin, New Jersey	Blue	
	Sterling, New Jersey	Blue	
Scheelite	Western United States	Bright Vivid Blue	
	Provinces of Canada	Bright Vivid Blue	
Sapphires	Different Locations	Yellow-Orange to Red	
Selenite			
	Fort Dodge, Iowa		Golden Yellow
	Hay Springs, Neb.	Pale Yellow	Pale Blue
	Lovington, N. M.	Yellow	Light Blue
	Morrison, Colorado		Greenish Blue
Schrockingergite	Wamsutter, Wyoming	Strong Yellow-Green	
Simpsonite	Western Australia	Blue White to Pale Yellow	
	Southern Rhodesia	Blue White to Pale Yellow	
	Brazil	Blue White to Pale Yellow	
*Smithsonite	Franklin, New Jersey	Yellow	

LIST OF FLUORESCENT MINERALS

MINERAL	LOCATION	FLUORESCENCE	PHOSPHORESCENCE
Sodalite	Moultonboro, N. H.	Orange-Red	
*Sphalerite	Franklin, New Jersey	Red, Blue	
	Iturbidie District in Mexico	Bright Orange	Bright Orange
	Tsumeb, Africa	Bright Orange	
Spinel	Ceylon	Bright Red	
	Vesuvius	Bright Red	
Spodumene	Portland, Conn.		Deep Red
Strontianite	California	Bluish Green	Bluish Green
	Germany	Bluish Green	Bluish Green
	England	Bluish Green	Bluish Green
*Svabite	Franklin, New Jersey	Red	
Terlinguaite	Terlingua, Texas	Yellow	
Thaumasite	Paterson, New Jersey		White
Topaz	Schneckenstein, Ger.	Light Green	
Tourmaline		Light Yellow Shades Only	
*Tremolite	Franklin, New Jersey	Blue, Cream	
	Lakeport, New York	Apricot-Pink to Red	
Trona	Searles Lake	Blue	Light Blue
Uranium Salts & Minerals	Varied Locations		
Autunite		Yellow Green	
Beta-Uranopilite		Yellow Green	
Beta-Uranotil		Yellowish	
Chalcoite		Yellow Green	
Gummite (variable)		Violet	
Johannite (variable)		Yellow Green	
Meta-Tobernite		Yellow Blue	
Schrockingergite		Green	
Tobernite		Yellow Green	
Uranocircite		Yellow Green	
Uraniferous Hyalite		Yellow Green	
Uranophane		Yellow Green	
Uranopilite		Yellow Green	
Uranospathite		Yellow Green	
Uranothallite		Green	
Uranotil		Yellowish	
Zippeite		Yellowish	
Wavelite	Mt. Holly, Penna.	Blue	
Wernerite	Ontario, Canada	Bright Yellow	
*Willemite	Casa Grande, Ariz.	Different Shades of Green	
	Franklin, New Jersey	Different Shades of Green	
	Superior, Arizona	Different Shades of Green	
Witherite	Hexham, England	Yellow	
*Wollastonite	Alaska	Golden Yellow	Blue Green
	Franklin, New Jersey	Orange	
	Pennsylvania	Golden Yellow	Blue Green
	Riverside, Calif.	Golden Yellow	Blue Green
Zippeite		Yellow Green (Strong)	
Zircon	Black Placer Sands of California	Brilliant Bright Orange	
	Brazil	Bright Orange	
	Idaho	Brilliant Bright Orange	
	Montana	Bright Orange	
	North Carolina	Bright Orange	
	Ontario, Canada	Bright Orange	
	Oregon	Brilliant Bright Orange	
	Wyoming	Bright Orange	

Fluorescent Minerals from Franklin, N. J., World Center of Fluorescent Mineral Collecting

APPENDIX B – LIST OF FLUORESCENT WOODS

WOOD	LOCATION	FLUORESCENCE
Aust. Blackwood	Australia	Yellow
Buttonbush	Ohio	Yellow
Camelthorn	N. Rhodesia	Green
Cajeput Tree	Venezuela	Bright Yellow
Coffeetree	Kentucky	Yellow
Cork-Tree	Manchuria	Yellow
Cucumber Tree	Penna.	Bright Yellow & Blue
Dwarf Sumac	Virginia	Yellow & Blue
Grapefruit	U.S.A.	Yellow
Honey Locust	Illinois	Bright Yellow
	Penna.	Bright Yellow
	Texas	Yellow
Judastree	U.S.A.	Yellow
Karee	So. Africa	Green & Yellow
Kattakumanjal	Ceylon	Yellow
Kentucky Coffee	Penna.	Yellow
Kentucky Coffeebean	Indiana	Yellow
Muninga	No. Rhodesia	Green
Mutanga	No. Rhodesia	Bright Yellow
Olive Tree	Italy	Bluish-White
Pawpaw	U.S.A.	Green & Yellow
Persimmon	Texas	Gray & Green
Plane Tree	Penna.	Light Blue -
Poison Ivy	Maryland	Yellow
	Penna.	Bright Yellow
Poison Sumac	Ohio	Yellow-Green
Poplar, Blue Stain	Penna.	Apricot, Pink & Blue
Potato Tree	Florida	Yellow
Redbud	Virginia	Yellow & Blue
Sangre	Mexico	Yellow
Scotch Broom	Oregon	Blue-White
Shining Sumac	Virginia	Yellow
Silk Tree	Virginia	Bright Yellow & Blue
Staghorn Sumac	Illinois	Bright Yellow
	Penna.	Yellow-Green
Tamarind	India	Blue-White
Thornless Locust	Missouri	Bright Yellow
Victorian Black Wattle	Australia	Yellow
White Pine	U.S.A.	Yellow
Yellow Locust	Ohio	Bright Yellow
Yellowwood	New Britain	Yellow